How Early Life Stress Impacts Gut Development and Long-Term Health

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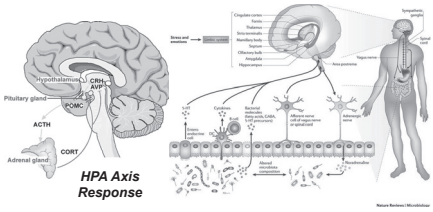
The Stress Response

The stress response is a homeostatic response meant for survival



HPA Axis Response

Benefits of the stress response:

- Mobilizes nutrients and resources necessary for survival
- Diverts blood flow and oxygen to cardiovascular system and muscles
- Boosts your immune system
- Behavioral changes

Inappropriate stress response leads to disease

Major factors impacting stress response and disease outcomes

- Number of stressors
- Duration – Acute vs chronic
- Age at which time stress occurs
- Nature/type of stress
- Biological Sex: Male vs. female

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ADSA Discover Conference, Itasca, IL

Stressors Erode Performance and Increase Disease Risk Across the Production Lifespan

Weaning

Mixing/Crowding

Diet change

Pathogen exposure

Processing

Transportation

Cold stress

Vaccinations

Heat stress

Significant Gaps in Knowledge:

- Mechanisms driving poor performance and increased disease risk are poorly understood
- Practical interventions are lacking

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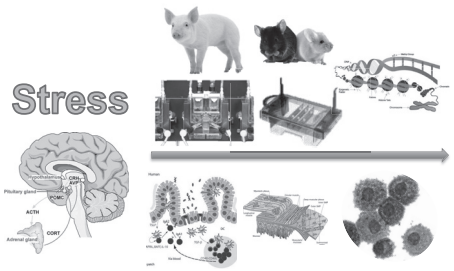
Gastrointestinal Stress Biology Laboratory

Research Focus: Mechanisms of stress-related gastrointestinal disorders

Stress



Animal Health

Human Health

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The Gut is Highly Sensitive to Stress

- Major Depressive Disorder
- Autism
- Parkinson's

Gut-Brain Axis

Stress-related GI disorders in people and Animals

- Irritable Bowel Syndrome (IBS)
- Inflammatory Bowel Disease (IBD)
- Infectious enteritis
- Functional diarrhea/constipation
- Performance reductions

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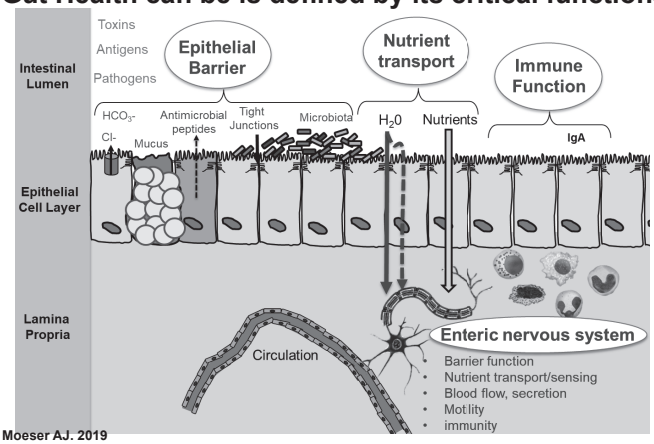
What is gut health and how do you measure it?

The Largest Interface with the Outside World

Impacts of Weaning Stress on Gut Barrier and Immune Function: Lessons learned from the pig

Gut Health can be is defined by its critical functions



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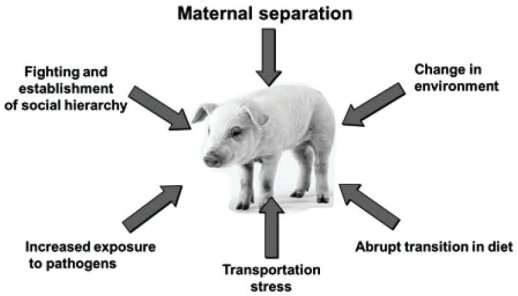
Weaning stress is the most significant early life stress



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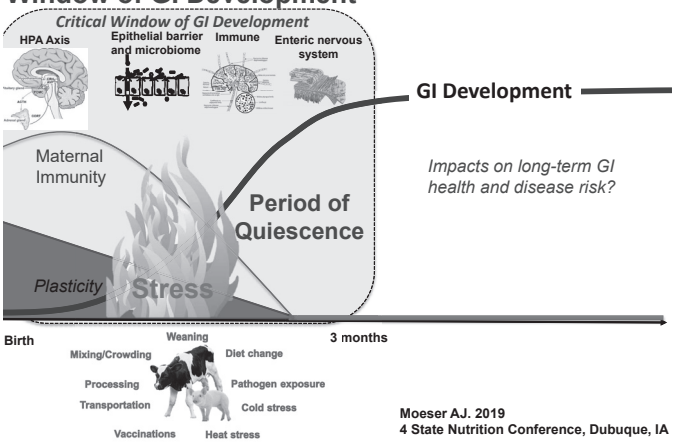
The First Three of Postnatal Life is a Critical Window of GI Development



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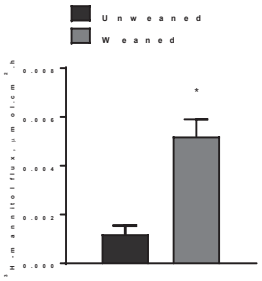
Impact of Early Weaning on Intestinal Barrier Function and Inflammation

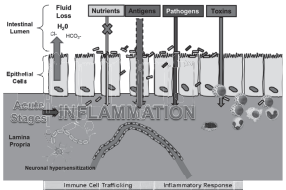
Intestinal permeability measurements on Ussing Chambers



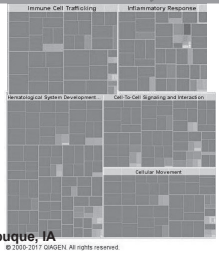
Wean age = 21 d

Moeser et al. *Am J Physiol Gastrointest Liver Physiol*. 292:G173-81

Leaky gut



Upregulated Immune Genes



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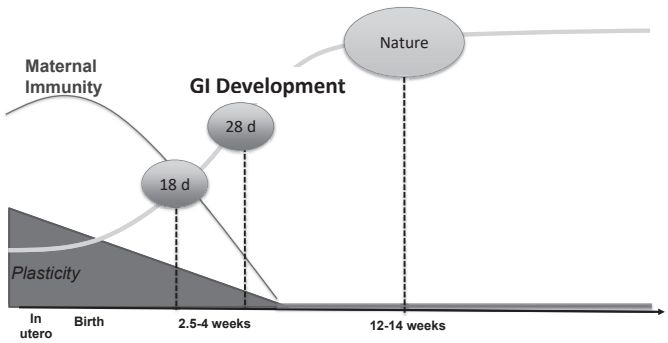
Does Weaning Age Matter?

Critical Window of GI Development



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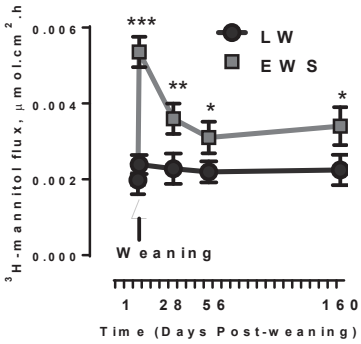
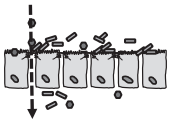
Long-term Impact of Early Weaning on Intestinal Barrier Function





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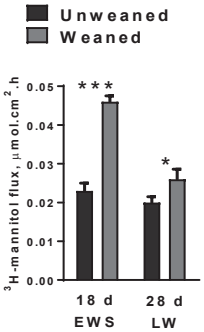
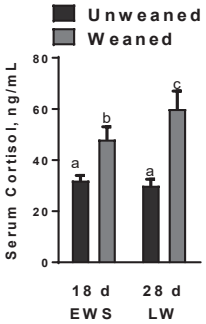
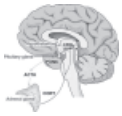
Early Weaned Pigs Have Greater Intestinal Barrier Injury In Response to Weaning



Are early weaned pigs more stressed?





EWS = Early weaning stress
LW = Late Weaning

Moeser et al. *Am J Physiol Gastrointest Liver Physiol.* 293:G413-21

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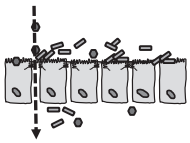
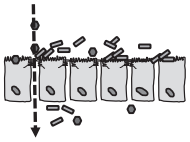
Does early weaning influence Responses to Later Life Challenges?

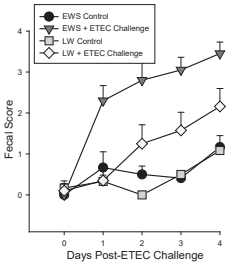


Are there long-term impacts of early weaning on gut health and disease risk?



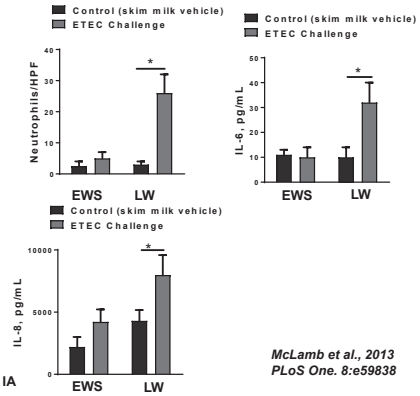
Early Weaning Stress Leads to Heightened Clinical Disease in Response to Subsequent Enterotoxigenic *E. coli* Challenge

Clinical Disease is more severe in early weaned pigs



EWS = 16-18 d wean age
LW = 22-24 wean age

Immune response is suppressed in early weaned pigs



McLamb et al., 2013
PLoS One. 8:e59838

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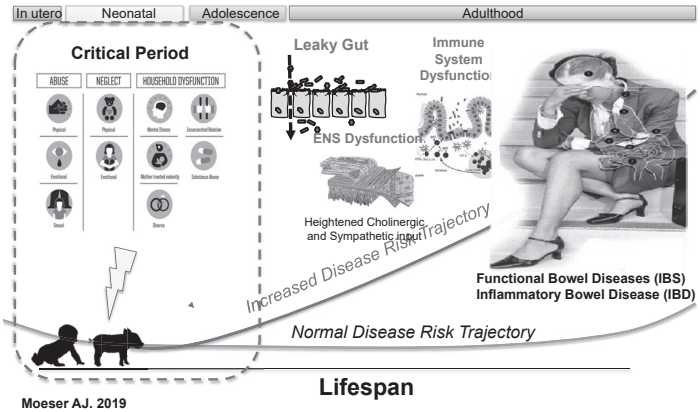
Early Life Stress and Long-term GI Development



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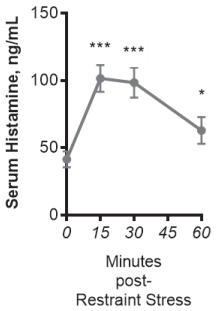
Mast Cells are Rapidly Activated in Response to psychological Stress



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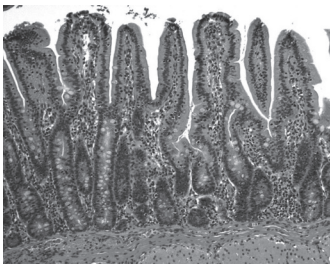
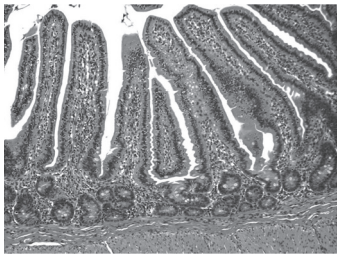
No Major Histological Differences Observed Between Early and Late Weaned PIgs



Late Weaned



Early Weaned

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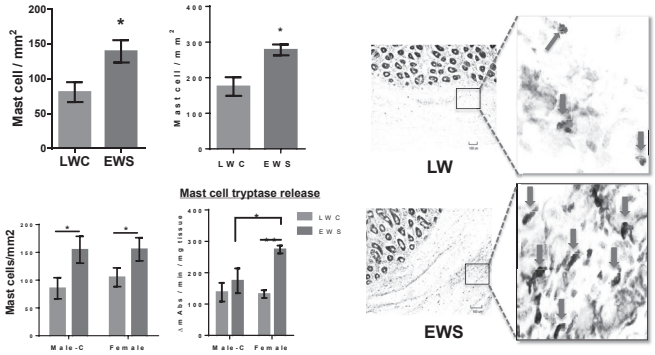
Early Weaning Stressed Pigs Exhibit Increased Intestinal Mast Cell Numbers and Mediator Release



Pohl et al, 2017 Neurogastroenterology and Motility (in press)

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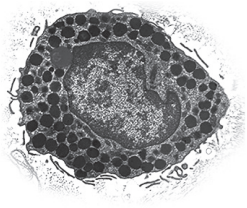
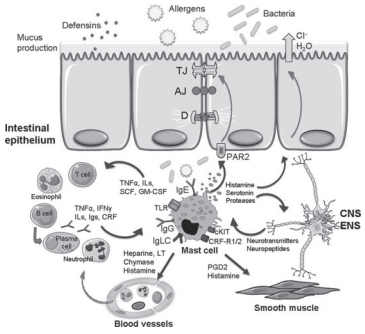
Mast Cells: Critical Innate Immune Effector Cells Playing Diverse Roles in Health and Disease



Beneficial roles
- Pathogen defense
- Wound repair
- Resolution of inflammation
- Tolerance

Deleterious roles (hyper-activation)
- Leaky gut
- Inflammation
- Chronic pain
- Anaphylaxis/allergy



Wouters et al 2015, Gut.

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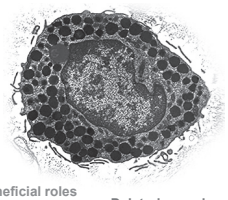

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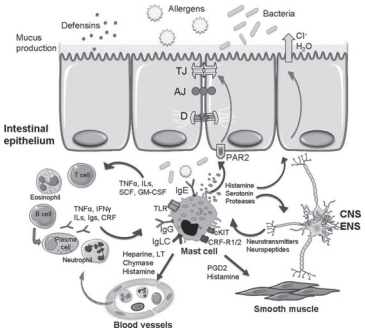

Wouters et al 2015, Gut.

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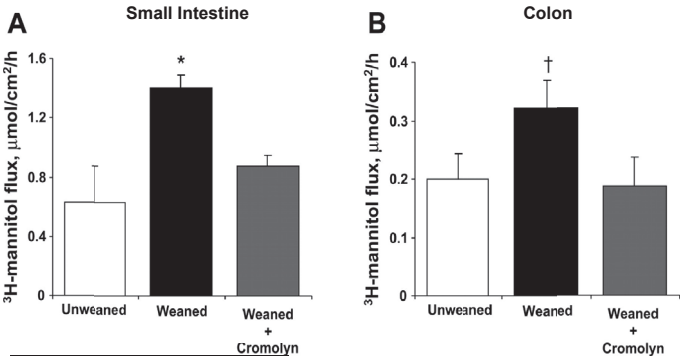
Mast Cells Are Critical Regulators of Weaning Stress-Induced Intestinal Permeability



Moeser et al. *Am J Physiol Gastrointest Liver Physiol.* 293:G413-21, 2007

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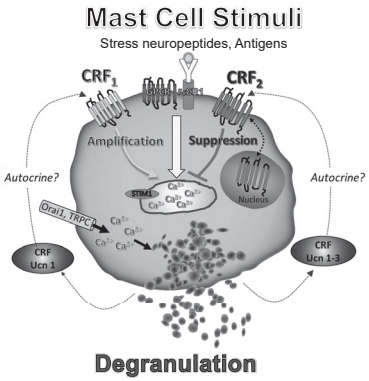
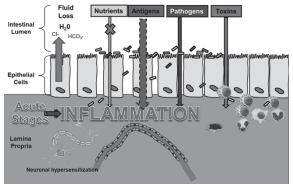
CRF1 and CRF2 are opposing regulators of mast cell degranulation and intestinal permeability





- Overman EL, Rivier JER, and Moeser AJ. 2012. *PLoS One.* 7(6):e39935
- Ayydurai, Moeser et al 2017 *J Leuk Biol*
- *D'Costa et al. 2018 (J Allergy Clin Immunol, in press)*

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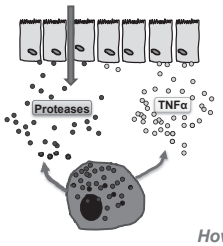
How do Mast cells Increase Intestinal Permeability?

Increased Intestinal Permeability



How are mast cells regulated by stress?

Overman EL, Rivier JER, and Moeser AJ. CRF Induces Intestinal Epithelial Barrier Injury via the Release of Mast Cell Proteases and TNFα. 2012. ***PLoS One.*** 7(6):e39935
Moeser et al 2017, *Animal Nutrition*
Ayydurai, Moeser et al 2017 *J Leuk Biol*

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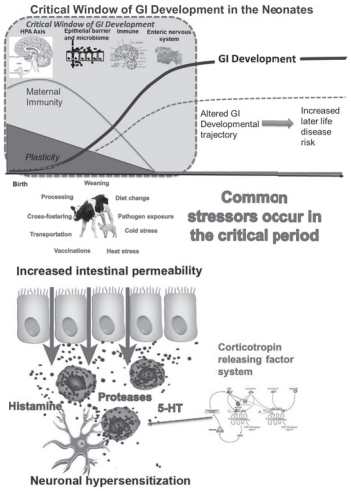

Take Home Points

- Common production stressors occur during the critical window of GI development
- Early weaning stress induces
  - Early gut barrier breakdown and inflammation
  - Altered development of the GI and immune system function
- **Mast cells** are critical immune drivers of stress-induced GI injury

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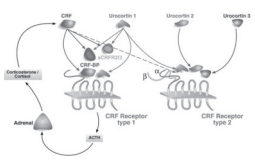
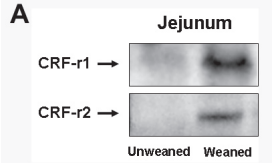
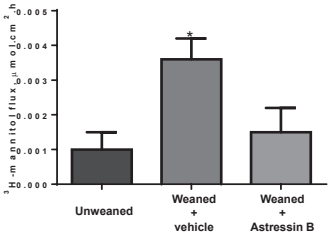
Upregulation of CRF Signaling Pathways in Early Weaned Pigs

CRF receptor system







CRF receptor antagonist drug

Moeser et al. *Am J Physiol Gastrointest Liver Physiol.* 292:G173-81

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Replacement Heifers: How Many, What Kind, and How Do We Manage it All?

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Replacement Heifers:
How Many, What Kind, and How do We Manage it All?

Michael Overton, DVM, MPVM

Advancements in Dairy Breeding and Selection have Created Both Opportunities and Challenges

- Formerly:
  - Bred everything (conventional)
  - Kept all heifers that did not die
- Currently – options:
  - Sex-sorted semen
  - Beef semen
  - IVF embryos (dairy or beef)
  - Genomic testing
- Many questions to consider:
  - What service sire should I use on each animal?
    - Conventional, sexed, beef, or embryo
    - How many heifers do I need to produce?
    - Which cows should produce my replacements?
  - Which heifers do I keep?
  - When do I cull heifers that I do not need?
  - Should I use genomic testing?
  - How many (and which) cows should I cull?

EM-US-19-0016

Common Question that I Get: "How Many Heifers Do I Need?

- "IT DEPENDS…"
- It depends on the question being asked and on the timing:
  - THIS month, need enough heifers to replace cows that need to be culled (or would like to cull)
  - If forecasting into the future…the questions can vary and the answers will vary based upon many factors:
    - How many do pregnancies do I need to produce?
    - How many do I need to place into the hutches?
    - How many do I need in inventory?

EM-US-19-0016

Producing More Pregnancies is Just the Start…

- Stillbirths – what percent of births result in dead calves?
- Mortality losses
- Heifer culling due to chronic disease issues
- Growth rate/nutritional management/age at first service
- Fertility – it's a bigger issue than many realize
- Abortions…Pregnancies must survive to term
- Adult herd culling needs
- Herd size plans (expansion, no change, contraction)

EM-US-19-0016

To Help Illustrate a Few of These Concepts, We'll Use a Data Set from Our Dairy Data Access System (DDAS)

(Convenience sample of 30 dairy herds from across the US)

- Populations used:
  - 30 herds from across the U.S. (all herds are >90% Holstein)
  - Average milking and dry, total across all herds = 99,955 cows
  - Average youngstock inventory, total across all herds = 104,264 heifers
  - Herd size range of 236 to 13,602, mean of 3,332
  - DairyComp 305® backups were from December 2018

EM-US-19-0016

When Considering "How Many Heifers Do I Need?", the Primary Consideration Should be the Anticipated Herd Turnover

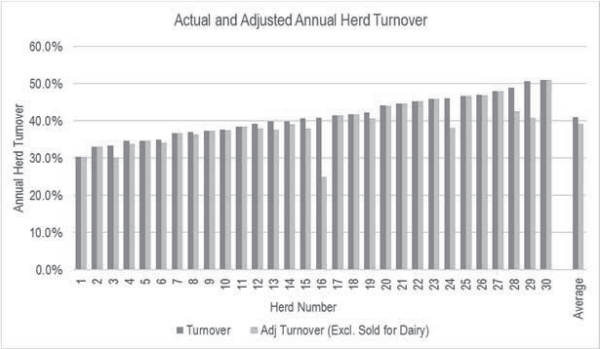
Herd Turnover:

$$\frac{\text{\# Cows (milking and dry) that leave the herd}}{\text{Average \# of Cows (milking and dry) for the year}}$$

- Wide range of observed values: < 20% to > 50%
- Very commonly observed (US): 35% to 45%
- Why is there so much variation amongst herds?

EM-US-19-0016

Holstein Data Set from DDAS System



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Think of a Dairy as a Closed Production System

- There is a certain capacity of animals (milking and dry)
  - If too many, overcrowded and decreased performance
  - If too few, inefficient dilution of fixed costs
- First priority: improve management in order to reduce the risk of cows losing value prematurely (death, disease, infertility, etc)
- THEN, culling should be driven by economics…
  - Based on what is better for the current and long term profitability of the herd and ***NOT some predetermined benchmark***

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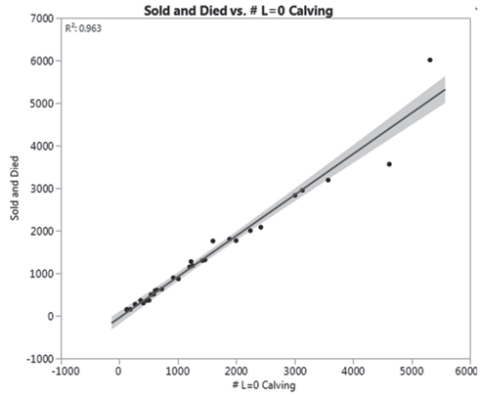
Heifer Numbers (or Availability) and Herd Turnover Are Highly Correlated (as expected)



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Given the Strong Relationship Between Heifer Numbers and Herd Turnover, What Factors Impact the Number of Heifers Produced?

- Reproductive performance – heifers and cows
- Sires used – conventional, sexed, or beef
- Stillbirth (DOA) risk – heifers and cows
- Heifer losses
  - Early:
    - Birth through weaning
    - Weaning to entrance to breeding pen
    - Breeding
  - Late:
    - Post-breeding to calving

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What Factors Impact the Number of Heifers Produced?

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What is the Relationship Between 21-d Pregnancy Rate (PR) and Calves Produced

- In reality, it depends on the pattern (timing) of pregnancy creation along with the herd's 21-d PR
- For this demonstration → our assumptions:
  - Herd with 1200 animals calving/year
  - Average abortion risk = 10%
  - Average culling risk = 34%
  - 10 21-d cycles of breeding eligibility

21-d PR	***16%***	***20%***	***23%***	***26%***	***28%***
% of Cows that Calve Again	*60%*	*63%*	*66%*	*67%*	*68%*
# Calves Produced	720	760	792	807	816
# Heifers Produced	346	365	380	387	392
Difference from lower PR		19	15	7	5

  - So, assuming 48:52% heifers:bulls and a 1000-cow dairy, a 28% PR in THIS demonstration would yield 46 more heifers, assuming all else being equal

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What Happens to Herd Turnover if Reproductive Performance Improves?

- If pregnancy creation efficiency improves (more pregnancies and fewer animals culled due to reproductive failure)
- AND assuming replacement heifer management and performance is unchanged
- AND service sires used are similar
- AND if herd size is stable…

  Herd Turnover MUST Increase

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About Those Service Sires…

- Traditionally, herds used natural service or AI with conventional semen
  - Expected 45-48% heifer calves
- 10-20 years ago, herds often struggled to reach 18-20% pregnancy rate
- As a result, herd turnover was limited (or producers purchased heifers as needed)
- Now, there are options!

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Potential Sire Options and Expected Fertility

Semen Type	Expected % Heifer Replacements	Fertility Impact
Conventional	46-48%	Baseline
Sex Sorted	Up to 90%	-20 to -25% but animal selection and superior management can result in lower impacts
Beef	0%	None to slight improvement

Karakaya-Bilen, E., et al. (2018). Reproduction in Domestic Animals: 1-8.
Vishwanath, R. and J. F. Moreno (2018). Animal 12(s1): s85-s96.

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Given that Heifer Numbers Typically Drive Herd Turnover, What Drives the Number of Heifers Produced?

- Reproductive performance – heifers and cows
- Sires used – conventional, sexed, or beef
- **Stillbirth (DOA) risk – heifers and cows**
- Heifer losses
  - Early:
    - Birth through weaning
    - Weaning to entrance to breeding pen
    - Breeding
  - Late:
    - Post-breeding to calving

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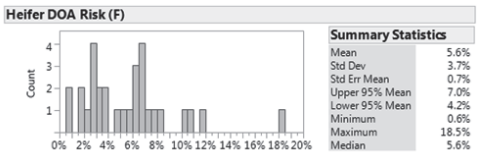
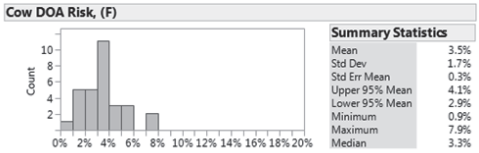
Stillbirth (DOA) Risk (same 30-herd data set)





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What Factors Impact the Number of Heifers Produced?

- Reproductive performance – heifers and cows
- Sires used – conventional, sexed, or beef
- Stillbirth (DOA) risk – heifers and cows
- **Heifer losses**
  - **Early:**
    - **Birth through weaning**
    - **Weaning to entrance to breeding pen**
    - **Breeding**
  - **Late:**
    - **Post-breeding to calving**

"What % become pregnant?"

"What % of pregnancies actually calve?"

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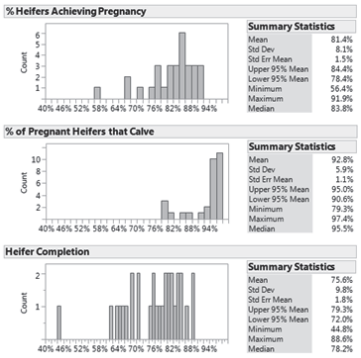
Heifer Dynamics
(birth through potential calving)



On average:

- 19% of heifers failed to achieve a pregnancy (but don't confuse this with a fertility issue)
  - Mortality
  - Culling (sold)
  - Repro failure (sold)
- 7% of pregnant heifers failed to calve
  - Abortion losses
  - Late culls
  - Late mortality

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Putting it all together…How Many Heifers Are Needed Annually?
(using results of 30-herd data set)

Milking and Dry	1200
Herd Turnover	39.0%
# Cows Culled = # Heifers Needed to Calve	468
% of Heifers Calving	75.5%
% Preg Heifers that Calve	92.8%
% Heifers that Conceive	81.4%
# Live Heifers Born	620
DOA Risk	5.6%
# Heifer Births Needed	656

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How Many Heifers are Needed Annually?
(Scenarios for Consideration)

Milking and Dry	1200	1200	1200	1200	1200	1200
Herd Turnover	30.0%	40.0%	50.0%	40.0%	40.0%	39.0%
# Culled = # Heifers Needed to Calve	360	480	600	480	480	468
% of Heifers Calving	83.6%	83.6%	83.6%	83.6%	73.6%	75.5%
% Preg Heifers that Calve	95.0%	95.0%	95.0%	95.0%	92.0%	92.8%
% Heifers that Conceive	88.0%	88.0%	88.0%	88.0%	80.0%	81.4%
# Live Heifers Born	431	574	718	574	652	620
DOA Risk	5.0%	5.0%	5.0%	3.0%	5.0%	5.6%
# Heifer Births Needed	453	604	755	592	686	656

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Different Approaches to Creating Sufficient Number of Heifers: Observations from the Field

- Very common:
  - Use sexed semen for 1-3 services in virgin heifers
- Increasingly common:
  - Also, use sexed semen for 1-2 services in lactation=1 +/- lactation=2
- In herds aggressively using sexed semen, now starting to see increased use of beef semen in lower end cows and heifers
- Some herds are trying to move to all sexed or beef; plan is to use NO conventional semen

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Putting it all together…Selecting Sires

Milking and Dry	1200
Herd Turnover	39.0%
# Culled = # Heifers to Calve	468
% of Heifers Calving	75.5%
% Preg Heifers that Calve	92.8%
% Heifers that Conceive	81.4%
# Live Heifers Born	620
DOA Risk	5.6%
# Heifer Births Needed	656
# Animals Conceiving	1200

		Option 1		Option 2		Option 3	
	%F	% Sires	# Heifers	% Sires	# Heifers	% Sires	# Heifers
% Convent.	48%	83%	480	50%	287	26%	150
% Sexed	88%	17%	175	35%	370	48%	506
% Beef	0%	0%	0	15%	0	26%	0
		100%	656	100%	656	100%	656

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Putting it all together…Selecting Sires

Milking and Dry	1200
Herd Turnover	39.0%
# Culled = # Heifers to Calve	468
% of Heifers Calving	75.5%
% Preg Heifers that Calve	92.8%
% Heifers that Conceive	81.4%
# Live Heifers Born	620
DOA Risk	5.6%
# Heifer Births Needed	656
# Animals Conceiving	1200

		Option 1		Option 2		Option 3		Option 4	
	%F	% Sires	# Heifers	% Sires	# Heifers	% Sires	# Heifers	% Sires	# Heifers
% Convent.	48%	83%	480	50%	287	26%	150	0%	0
% Sexed	88%	17%	175	35%	370	48%	506	62%	656
% Beef	0%	0%	0	15%	0	26%	0	38%	0
		100%	656	100%	656	100%	656	100%	656

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Producing a Large Excess of Heifers Has Become an Economic Concern

- Due to a combination of excess heifer inventory and low milk prices, replacement heifer values have plummeted and are well below actual cost of production:

	Jan-18	Oct-18	Jan-19
Arizona	$1,700	$1,450	$1,250
California	$1,500	$1,200	$1,100
Florida	$1,530	$1,260	$1,250
Idaho	$1,600	$1,350	$1,120
Michigan	$1,600	$1,400	$1,180
Minnesota	$1,500	$1,200	$1,050
New York	$1,750	$1,450	$1,040
Ohio	$1,450	$1,100	$1,000
Pennsylvannia	$1,440	$1,400	$1,050
Texas	$1,600	$1,450	$1,300
Virginia	$1,370	$1,120	$970
Wisconsin	$1,470	$1,180	$1,120
United States	**$1,520**	**$1,230**	**$1,140**

Source: USDA NASS Ag Prices Report, March 28,2019, p. 21
https://downloads.usda.library.cornell.edu/usda-esmis/files/c821gj76b/f7623m42k/k0698f528/agpr0319.pdf, last accessed on 4/20/2019

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Estimating the Cost per Heifer Raised

Assumptions used in the model:

- Newborn heifer value $60
- Birth weight 88 lbs
- Breeding weight 884 lb (57% of mature weight & 51" WH)
- Labor/ hr $15
- Interest 6%
- AI cost/ service $18
- Large dairy using hutches, 100% milk replacer, outdoor housing, and TMR feeding

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Estimated Cost of Raising Heifers

Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up	Total	Stage
Birth to 2	2 to 4	4 to 10	10.0-15.3	15.3-20.9	20.9-22.9	22.8	Age in months
3.50%	1.75%	1.00%	0.50%	0.30%	0.25%	7.30%	Mortality
0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	6.5%	Culled (sold)
$16						16	Colostrum*
$164						164	Milk*
$22						22	Starter*
	$71					71	Grain*
	$5					5	Hay*
		$217	$262	$311	$153	943	Feed (TMR)*
$203	$76	$217	$262	$311	$153	$1,296	Total Feed*
$48	$10	$12	$33	$14	$30	$158	Labor*
$18	$5	$8	$3	$3	$15	$55	Vet Med/ Health*
			$35	($61)		($24)	Breeding & Culls*
$30	$19	$12	$11	$13	$7	$100	Housing and Other*
$2	$3	$16	$24	$34	$14	$97	Interest*
$301	$113	$266	$368	$313	$220	$1,682	Total Cost*
$4.78	$1.92	$1.45	$2.11	$1.83	$3.61	$2.37	Cost/ Day
88	198	325	702	1037	1341		Entering Weight (lb)
198	325	702	1037	1341	1443	1443	Exit Weight (lb)
1.75	2.16	2.06	1.92	1.77	1.68		Average daily gain (lb)
1.75	1.95	2.02	1.98	1.93	1.91	1.91	Cumulative ADG (lb)
							Cumulative from birth
$301	$419	$689	$1,061	$1,457	$1,682	$1,682	Total Cost*
$4.78	$3.44	$2.26	$2.22	$2.24	$2.37	$2.37	Cost/ Day*
$364	$484	$756	$1,130	$1,534	$1,760	$1,760	Cost Including Wet Calf*

* Adjusted for death loss

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Estimated Cost of Raising Heifers

Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up	Total	Stage
Birth to 2	2 to 4	4 to 10	10.0-15.3	15.3-20.9	20.9-22.9	22.8	Age in months
3.50%	1.75%	1.00%	0.50%	0.30%	0.25%	7.30%	Mortality
0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	6.5%	Culled (sold)
$16						16	Colostrum*
$164						164	Milk*
$22						22	Starter*
	$71					71	Grain*
1.75	1.95	2.02	1.98	1.93	1.91	1.91	Cumulative ADG (lb)
							Cumulative from birth
$301	$419	$689	$1,061	$1,457	$1,682	$1,682	Total Cost*
$4.78	$3.44	$2.26	$2.22	$2.24	$2.37	$2.37	Cost/ Day*
$364	$484	$756	$1,130	$1,534	$1,760	$1,760	Cost Including Wet Calf*

Cumulative Cost by End of Each Stage

Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up
Birth to 2	2 to 4	4 to 10	10.0-15.3	15.3-20.9	20.9-22.9
$364	$484	$756	$1,130	$1,534	**$1,760**

* Adjusted for death loss

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For the Next Slide, Will Examine the Cost of Extra Culling during the Raising Period

(over and above mortality and reproductive culling)

- Assumptions:
  - Same baseline assumptions as before
  - Same mortality risk by stage
  - Initial heifer population = 1,000
    - 50 culled after weaning
    - 40 culled after the grower
  - Cull values based on projected body weight at time of culling and published market values for slaughter Holstein heifers (4 sources around the US)

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Culling Loss Estimates

Starting age	0.0	2.1	4.1	10.1	15.3	20.9
Ending Age (mos)	**2.1**	**4.0**	**10.0**	**15.2**	**20.8**	**22.8**
Number of performance culls for stage	0	50	40	0	0	0
Median days to cull for stage	63	14	14	30	60	14
Total Cost for heifer completing stage	$364	$498	$786	$1,164	$1,574	$1,802
Weight of cull (lb)		229	354	760	1143	1364
Beef value ($/lb)		$0.71	$0.77	$0.74	$0.69	$0.90
Beef value ($/head)		$162	$273	$562	$789	$1,200
Cost of raising to point of cull		-$413	-$531	-$854	-$1,301	-$1,608
Loss per heifer culled		**-$251**	**-$258**	**-$291**	**-$513**	**-$408**

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Comparison of Baseline vs. Culling Strategy

Baseline							Culling Strategy					
Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up	Stage	Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up
Birth to 2	2 to 4	4 to 10	10.0-15.7	15.7-21.4	21.4-23.4	Age in months	Birth to 2	2 to 4	4 to 10	10.0-15.7	15.7-21.4	21.4-23.4
3.50%	1.75%	1.00%	0.50%	0.30%	0.25%	7.3% Mortality 7.1%	3.50%	1.75%	1.00%	0.50%	0.30%	0.25%
0.0%	0.0%	0.0%	0.0%	7.0%	0.0%	6.5% Culled (sold) 14.9%	0.0%	5.2%	4.5%	0.0%	7.0%	0.0%
$16						Colostrum*	$16					
$164						Milk*	$164					
$22						Starter*	$22					
	$71					Grain*	$0	$72				
	$5					Hay*	$0	$5				
		$217	$262	$311	$153	Feed (TMR)*	$0		$218	$262	$311	$153
$203	$76	$217	$262	$311	$153	Total Feed*	$203	$77	$218	$262	$311	$153
$48	$10	$12	$33	$14	$30	Labor*	$48	$10	$13	$35	$15	$32
$18	$5	$8	$3	$3	$15	Vet Med/ Health*	$18	$5	$9	$3	$3	$15
$0	$0	$0	$35	($61)	$0	Breeding & Culls*	$0	($9)	($13)	$35	($62)	$0
$30	$19	$12	$11	$13	$7	Housing and Other*	$30	$20	$13	$12	$14	$8
$2	$3	$16	$24	$34	$14	Interest*	$2	$4	$17	$24	$35	$15
$301	$113	$266	$368	$313	$220	Total Cost*	$301	$107	$256	$371	$316	$222
$4.78	$1.92	$1.45	$2.11	$1.83	$3.61	Cost/ Day	$4.78	$1.82	$1.40	$2.13	$1.84	$3.65
88	198	325	702	1037	1341	Entering Weight (lbs)	88	198	325	702	1037	1341
198	325	702	1037	1341	1443	Exit Weight (lbs)	198	325	702	1037	1341	1443
1.75	2.16	2.06	1.92	1.77	1.68	Average daily gain (lbs)	1.75	2.16	2.06	1.92	1.77	1.68
1.75	1.95	2.02	1.98	1.93	1.91	Cumulative ADG (lbs)	1.75	1.95	2.02	1.98	1.93	1.91
						Cumulative from birth						
$301	$419	$689	$1,061	$1,457	$1,682	Total Cost*	$301	$430	$711	$1,087	$1,489	$1,715
$4.78	$3.44	$2.26	$2.22	$2.24	$2.37	Cost/ Day*	$4.78	$3.53	$2.34	$2.27	$2.29	$2.41
$364	$484	$756	$1,130	$1,534	$1,760	Cost Including Wet Calf*	$364	$498	$786	$1,164	$1,574	$1,802

Comparison of Baseline vs. Culling Strategy

Baseline

Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up
Birth to 2	2 to 4	4 to 10	10.0-15.7	15.7-21.4	21.4-23.4
$364	$484	$756	$1,130	$1,534	$1,760

Culling Strategy

Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up
Birth to 2	2 to 4	4 to 10	10.0-15.7	15.7-21.4	21.4-23.4
$364	$498	$786	$1,164	$1,574	$1,802

What if I Already Have Too Many Heifers in the Pipeline? (current youngstock plus known pregnancies)

- Options:
  - Do nothing now – current cash flow drain…
    - Sell springers later (hope for higher prices…)
    - Cull more cows (possibly for dairy purposes?)
    - Expand the herd
  - Cull some heifers
    - Which should you cull?
    - When should you cull them?
- Plan to breed more selectively moving forward

Can We Use Data Contained In The Record System To Make Improved Culling Decisions?

- What data are useful predictors?
- What impact does culling some heifers have on the cost of the ones that successfully complete the raising process and calve?
- What is the value of using data during the heifer raising period to cull heifers at high risk for poor first lactation performance?

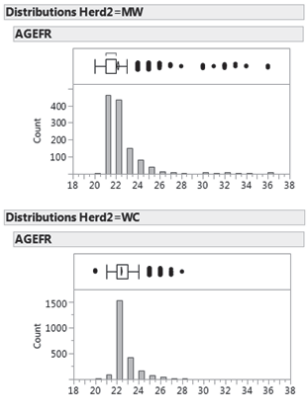
Herd Data Analysis

- Two large dairy herds from two geographically diverse areas of US
- Heifers born during 2013 were evaluated using records from DC305
- Goals:
  - Determine if potential culling candidates can be accurately identified during the heifer rearing process
  - What is the value of using this approach if there are more heifers than needed in the pipeline?

Inclusion Criteria

- Heifers had to have the following information recorded to be included in the project:
  - Current Dairy Gain 2 (CDG2) – daily gain adjusted to a 61-d weaning age
  - Predicted Transmitting Ability – Milk (PTAM)
  - Current Dairy Gain 3 (CDG3) – daily gain adjusted to 91-d of age

Descriptive Information about the Two Herds



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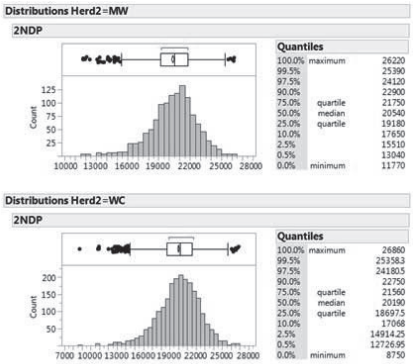

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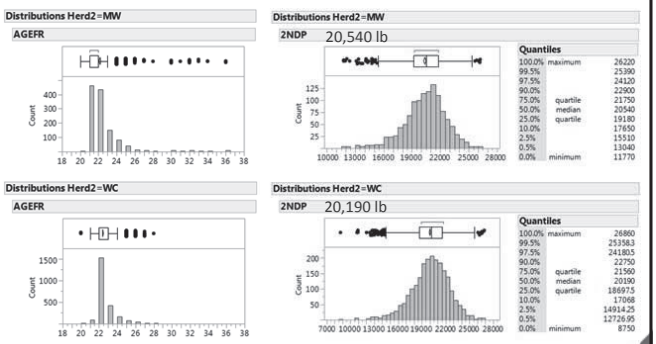
Descriptive Information about the Two Herds



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Developed Three Potential Approaches (Models) for Consideration in Selecting the "Wean Culls"

- Original Approach: Select heifers that are below the lower quartile cut points for CDG2 *and* PTAM
- More Selective: Select heifers that are below the lower quartile cut points (CDG2 and PTAM) *and* had Pneumonia recorded by 60 d of age
- Less Selective: Select heifers that are below the lower quartile cut points (CDG2 and PTAM) *or* had Pneumonia recorded by 60 d of age

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Created Culling Criteria for Post-Weaning Evaluation

- First, eliminated the heifers that died or were sold by the dairy prior to 63 days of age
- Then, if below the lower quartile for both CDG2 (1.64) *and* PTAM (46), identified them as "Wean Cull"

Frequencies		
Level	Count	Prob
Farm Removed	30	0.02209
Not Wean Cull	1229	0.90501
Wean Cull	99	0.07290
Total	1358	1.00000

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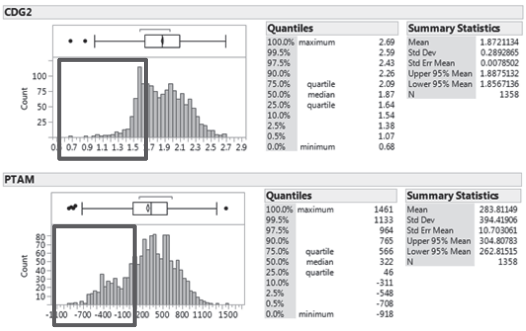
First Herd: MW



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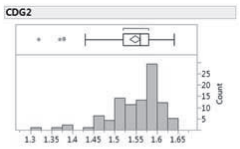
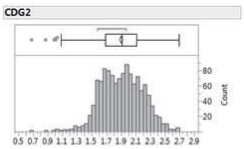
Culled at Weaning



Quantiles		
100.0%	maximum	1.64
99.5%		1.64
97.5%		1.64
90.0%		1.62
75.0%	quartile	1.58
50.0%	median	1.56
25.0%	quartile	1.52
10.0%		1.47
2.5%		1.38
0.5%		1.32
0.0%	minimum	1.32

Summary Statistics	
Mean	1.5491919
Std Dev	0.0601813
Std Err Mean	0.0060484
Upper 95% Mean	1.5611949
Lower 95% Mean	1.5371889
N	99

Not Culled at Weaning



Quantiles		
100.0%	maximum	2.69
99.5%		2.60
97.5%		2.44
90.0%		2.27
75.0%	quartile	2.12
50.0%	median	1.91
25.0%	quartile	1.69
10.0%		1.58
2.5%		1.38
0.5%		1.04
0.0%	minimum	0.68

Summary Statistics	
Mean	1.9049634
Std Dev	0.283649
Std Err Mean	0.0080911
Upper 95% Mean	1.9208372
Lower 95% Mean	1.8890896
N	1229

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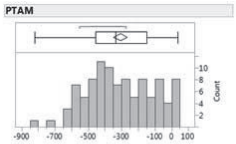
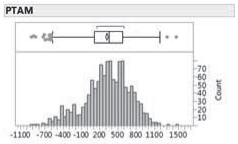
Culled at Weaning



Quantiles		
100.0%	maximum	36
99.5%		36
97.5%		32
90.0%		-12
75.0%	quartile	-149
50.0%	median	-337
25.0%	quartile	-456
10.0%		-553
2.5%		-666
0.5%		-820
0.0%	minimum	-820

Summary Statistics	
Mean	-306.7172
Std Dev	199.28203
Std Err Mean	20.028598
Upper 95% Mean	-266.9711
Lower 95% Mean	-346.4633
N	99

Not Culled at Weaning



Quantiles		
100.0%	maximum	1461
99.5%		1130
97.5%		964
90.0%		778
75.0%	quartile	573
50.0%	median	353
25.0%	quartile	112
10.0%		-220
2.5%		-489
0.5%		-686
0.0%	minimum	-918

Summary Statistics	
Mean	326.77705
Std Dev	367.21187
Std Err Mean	10.47468
Upper 95% Mean	347.32731
Lower 95% Mean	306.2268
N	1229

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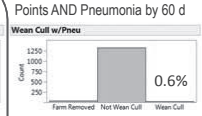
Results of Different Approaches for Selecting "Wean Culls"

Original Approach

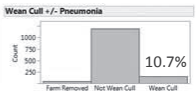
Frequencies		
Level	Count	Prob
Farm Removed	30	0.02209
Not Wean Cull	1229	0.90501
Wean Cull	99	0.07290
Total	1358	1.00000

More Selective: Below Cut Points AND Pneumonia by 60 d



Frequencies		
Level	Count	Prob
Farm Removed	30	0.02209
Not Wean Cull	1320	0.97202
Wean Cull	8	0.00589
Total	1358	1.00000

Less Selective: Below Cut Points OR Pneumonia by 60 d



Frequencies		
Level	Count	Prob
Farm Removed	30	0.02209
Not Wean Cull	1183	0.87113
Wean Cull	145	0.10677
Total	1358	1.00000

	Original Approach	More Selective	Less Selective
Not Wean Cull minus Wean Cull (LS Means)	1249 lb	1421 lb	813 lb
Not Wean Cull minus Full Population (LS Means)	625 lb	711 lb	406 lb

Continued the analysis with the Original Approach

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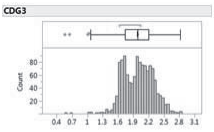
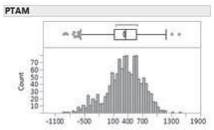
Next, "Removed" the "Wean Cull" Heifers and the Farm-Removed Heifers Prior to 120-d and Re-Evaluated the Performance of the Remaining Heifers at 120 d of Age



Quantiles		
100.0%	maximum	2.82
99.5%		2.70
97.5%		2.52
90.0%		2.35
75.0%	quartile	2.20
50.0%	median	1.99
25.0%	quartile	1.74
10.0%		1.63
2.5%		1.52
0.5%		1.08
0.0%	minimum	0.56

Summary Statistics	
Mean	1.9853621
Std Dev	0.2896054
Std Err Mean	0.008261
Upper 95% Mean	2.0015693
Lower 95% Mean	1.9691549
N	1229



Quantiles		
100.0%	maximum	1461
99.5%		1130
97.5%		964
90.0%		778
75.0%	quartile	573
50.0%	median	353
25.0%	quartile	112
10.0%		-220
2.5%		-489
0.5%		-686
0.0%	minimum	-918

Summary Statistics	
Mean	326.77705
Std Dev	367.21187
Std Err Mean	10.47468
Upper 95% Mean	347.32731
Lower 95% Mean	306.2268
N	1229

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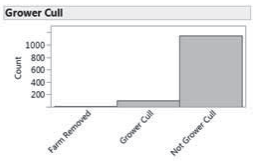
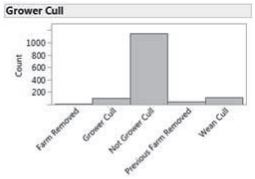
Created Culling Criteria for Grower Evaluation

- If below the lower quartile for CDG3 (1.74) and PTAM (112), identified them as "Grower Cull"



Frequencies		
Level	Count	Prob
Farm Removed	3	0.00244
Grower Cull	91	0.07404
Not Grower Cull	1135	0.92352
Total	1229	1.00000



Frequencies		
Level	Count	Prob
Farm Removed	3	0.00221
Grower Cull	91	0.06701
Not Grower Cull	1135	0.83579
Previous Farm Removed	30	0.02209
Wean Cull	99	0.07290
Total	1358	1.00000

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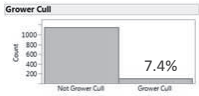
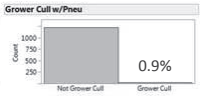
Repeated the Three Different Selective Models as with the Weaning Evaluation

Original Approach



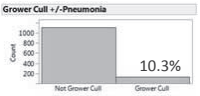
Frequencies		
Level	Count	Prob
Not Grower Cull	1135	0.92577
Grower Cull	91	0.07423
Total	1226	1.00000

More Selective: Below Cut Points AND Pneumonia by 120 d



Frequencies		
Level	Count	Prob
Not Grower Cull	1215	0.99103
Grower Cull	11	0.00897
Total	1226	1.00000

Less Selective: Below Cut Points OR Pneumonia by 120 d



Frequencies		
Level	Count	Prob
Not Grower Cull	1100	0.89723
Grower Cull	126	0.10277
Total	1226	1.00000

	Original Approach	More Selective	Less Selective
Not Grower Cull minus Grower Cull (LS Means)	561 lb	908 lb	309 lb
Not Grower Cull minus Full Population (LS Means)	281 lb	454 lb	155 lb

Continued the analysis with the Original Approach

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Repeated the Process for Herd WC

Herd Comparisons

CDG2		MW	WC	CDG3		MW	WC
Original Model	% Culled	7.3%	6.9%	Original Model	% Culled	7.4%	3.9%
	Difference	1249 lb	911 lb		Difference	561 lb	1082 lb
	Lift	625 lb	456 lb		Lift	281 lb	541 lb
More Selective	% Culled	0.6%	1.6%	More Selective	% Culled	0.9%	1.0%
	Difference	1421 lb	1280 lb		Difference	908 lb	1136 lb
	Lift	711 lb	640 lb		Lift	454 lb	568 lb
Less Selective	% Culled	10.7%	21.6%	Less Selective	% Culled	10.3%	18.7%
	Difference	813 lb	634 lb		Difference	309 lb	602 lb
	Lift	406 lb	317 lb		Lift	155 lb	300 lb

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Assuming that We Can Predict Which Heifers will be of Lower Value, What is the Impact on the Cost of Raising?

- To examine this question, created three scenarios:
  - Cull selected heifers post-weaning
  - Cull selected heifers post-weaning and post-grower
  - Cull selected heifers post-weaning and at springer stage
- Assumptions used:
  - Housing costs are fixed: i.e., with additional selective culling, cost/remaining heifer for cost of housing increases
  - Labor costs are partially fixed: i.e., with additional selective culling, cost/remaining heifer are treated as 50% fixed, 50% variable based on # of heifers

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Estimated Value Minus Raising Cost for Each Scenario by Herd (using modeled least square means estimates)

Herd MW	Scenario 1: Cull Selected Heifers at Post-Weaning			Scenario 2: Cull Selected Heifers at Post-Weaning and Post-Grower			Scenario 3: Cull Selected Heifers at Post-Weaning and at Springer Stage		
	Baseline	Scenario	Net	Baseline	Scenario	Net	Baseline	Scenario	Net
Total Raising Cost per Heifer Calving	($1,760)	($1,793)	($33)	($1,760)	($1,833)	($73)	($1,760)	($1,840)	($80)
Predicted Value per Heifer Calving	$1,760	$1,934	$174	$1,760	$1,838	$78	$1,760	$1,838	$78
Net Benefit (or Cost) of Scenario			$141			$5			($2)

Herd WC	Scenario 1: Cull Selected Heifers at Post-Weaning			Scenario 2: Cull Selected Heifers at Post-Weaning and Post-Grower			Scenario 3: Cull Selected Heifers at Post-Weaning and at Springer Stage		
	Baseline	Scenario	Net	Baseline	Scenario	Net	Baseline	Scenario	Net
Total Raising Cost per Heifer Calving	($1,760)	($1,793)	($33)	($1,760)	($1,812)	($52)	($1,760)	($1,817)	($57)
Predicted Value per Heifer Calving	$1,760	$1,887	$127	$1,760	$1,911	$151	$1,760	$1,911	$151
Net Benefit (or Cost) of Scenario			$94			$99			$94

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With Good Data and Careful Analyses, Selective Pressure Can Be Applied to Replacement Programs to Improve the Quality of Heifers Calving

- BUT, there MUST be extra heifers for this program to work
  - In these examples, and extra 14.7% or 10.8% of heifers were culled, depending on the herd
  - MUST have good records to make more accurate decisions
- This approach needs to be repeated across herds to validate the process
- Highly unlikely that a single modeling approach will work across all herds
  - Will need to develop customized approaches for each herd

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Summary

- Advancements in dairy breeding and selection have created opportunities and challenges for dairies
- Careful management can promote faster genetic progress and improved cash flow
  - Sexed semen to top animals, beef semen on bottom cows
  - But remember the fertility impacts as well…
- Err on the side of caution in terms of heifer numbers
  - A large excess is costly but not having enough to cull properly might be more costly in the long term
- By using growth performance and genetic information, excess heifers can be culled, leading to better quality heifers at calving (but there are still costs…)
- Finally, strive to reduce the risk of premature loss of value in heifers (and in cows) through improved feeding, housing, and preventive care
  - But, replace animals in a timely manner based on economic decision making

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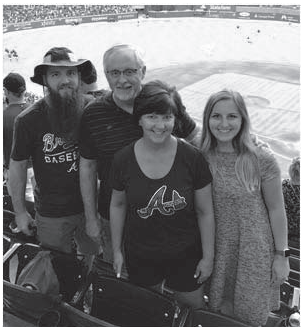
Thanks For Your Attention!



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Cattle Welfare: Understanding Welfare Standards to Protect and Uncover Profit Opportunities

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Introduction

The topic of animal welfare in the dairy industry resonates strongly with the general public today as both consumers and livestock caregivers demonstrate growing interest in the quality of life of dairy animals. Over the past several decades, there has been great progress seen within the dairy industry; however, the welfare conversations and future vision of dairy farming is continuously evolving (Weary and von Keyserlingk, 2017). For instance, research questions and ethical decisions for animal welfare in the 1983 dairy industry were centered on behavior, stress, objective assessments, animal sentience, and a moral obligation to maximize welfare (Fox et al., 1983). Whereas in 2017, welfare efforts and focus have been centered on balanced and applicable science, objective and subjective assessments, increasing two-way engagement with concerned people, demonstrate compliance with accepted standards, and positioning the industry as a leader in welfare (Weary and von Keyserlingk, 2017). As the focus of discussion, training, and action in the welfare space continues to evolve, there have been many standards and resources developed to assess and address such issues in the dairy industry, amongst other livestock industries (FARM, 2019; PAACO, 2019; OIE, 2019). In order for welfare science and expert guidance to continuously drive effective advancements in the dairy industry, animal welfare issues must be addressed in a holistic manner whereby aspects beyond health and production of cattle welfare are met, in addition to the welfare needs of their caregivers (von Keyserlingk et al., 2009).

Welfare Standards and Tools

The area of welfare science, standards, and policy is vast. Animal welfare standards for livestock take the form of laws, guidelines and certification programs (Weimer et al., 2018). When cattle caregivers adopt appropriate practices relevant to their region and segment within the dairy industry, it is important that they understand (1) the accepted standards and (2) the ways of demonstrating compliance to such standards. The three schools of welfare (Fraser et al., 1997) have served as the scientific basis for most accepted standards and/or definitions of animal welfare and encompass the biological functioning, affective state, and natural living conditions of an animal. Although the three schools are widely recognized among the scientific and research community, the importance of understanding and applying this basic framework at the caregiver level is critical during training exercises and protocol development that is grounded on accepted standards. Given that the three schools can and do overlap, the management of cattle should extend beyond measures of health and production to include the mental state and behavioral expression of animals (von Keyserlingk et al., 2009).

There are two federal livestock animal welfare laws in the U.S, which are limited to animal transportation and slaughter: the Twenty-Eight Hour Law and the Humane Methods of Slaughter Act. Currently, there are no U.S. federal laws that regulate the management of livestock and poultry, however, various animal industry groups have established voluntary guidelines containing best management practices (Weimer et al., 2018). Welfare definitions, guidelines, and audits for dairy cattle are available on both the domestic and global scale, including those published by the National Milk Producers Federation (FARM, 2019), the World Organization for Animal Health (OIE, 2019), the Professional Animal Auditing Certification Organization (PAACO, 2019), and many other standards provided by private organizations (for example, Dean Foods Dairy Stewardship Program). Given that consumer skepticism continues to grow and there is a wide range of personal values and beliefs that drive welfare concerns and buying behaviors across consumers (CFI, 2017; von Keyserlingk et al., 2009), it is important to ensure that dairy managers and cattle caregivers remain science-based in their practices and can demonstrate compliance to accepted standards. Several methods of verifying compliance exist, which include obtaining certification by a 1st, 2nd, and/or 3rd party auditor (Weimer et al., 2018). The 1st and 2nd party auditors may not be considered as fully independent by an outsider (because 1st party auditors are employed by the dairy company and 2nd party auditors are employed by a stakeholder group or allied industry); however, they are the parties that help implement the changes needed in practices

and culture as identified by the assessment/audit. Third-party auditors are independently contracted, and therefore have no association with the producer and are not invested in the success of the producer's dairy. Thus, a 3rd party auditor may bring a level of confidence to outsiders given the nature of their unbiased and independent position, but this should be balanced with the recognition that these auditors do not directly drive change at the farm level.

Overcoming welfare issues as an industry

It is critical that the dairy industry is committed to working together and communicating as an industry to find solutions that address industry-wide welfare concerns. One particular welfare issue that will require an industry-wide approach in leadership is the issue of compromised culled dairy cows arriving at slaughter facilities. Although this is a significant welfare concern recognized by many within the supply chain, compromised dairy cattle that are unfit for transport continue to arrive at slaughter facilities in the U.S., which casts doubt on the priorities that supply chain stakeholders have on production and finances versus cow welfare (Edwards-Callaway et al., 2019). One example that can be learned on addressing welfare issues affecting multiple stakeholders is the response and actions taken by the beef industry when significant observations were made on impaired fed cattle mobility in 2013 (AVMA, 2013). In addressing this issue as an industry, the feedlot, packer, and allied industry segments came together and not only established new methods of scoring cattle specific to this welfare concern, but developed research studies and industry benchmarking programs to monitor trends in abnormal mobility across the U.S. and understand the factors associated with impaired mobility for the betterment of beef cattle and the industry (Edwards-Callaway et al., 2017). The development of these tools has brought increased awareness and training emphasis on the importance of low-stress strategies during the final feeding and transport stages of fed cattle.

Another important area that will be critical for the dairy industry to work in partnership across all stakeholders within the supply chain includes overcoming the barriers that affect the welfare of the workforce-the 'boots on the ground' workers and drivers that directly interact with cattle (Hagevoort et al., 2013; Daigle and Ridge, 2018). It is known that dairy farming is among the most dangerous of occupations and modern dairies have become increasingly reliant on the diverse immigrant workforce (many with little dairy experience) to perform the critical responsibilities of cattle care and feeding, particularly as dairy businesses and productivity expand (Hagevoort et al., 2013; Hagevoort et al., 2017; Daigle and Ridge, 2018). In addition to the language and literacy barriers, there are many other challenges that workers likely encounter on and off the farm that can have direct and indirect impacts on the care and attention they provide to cattle. For instance, there may be internal farm challenges and external personal challenges that may impact worker performance in the workplace, affect the animals in their care, and ultimately result in high turnover rates typically seen in the agricultural sector (Daigle and Ridge, 2018). Unfortunately, there are very little to no metrics available to effectively quantify or evaluate dairy worker performance, job satisfaction, and related impacts on cattle welfare and productivity (Hagevoort et al., 2013; Hagevoort et al., 2017). There is also a disconnect on the value placed on stockpeople (compensation, workload, ergonomics, perception by society, etc.) and this subject is not often proactively addressed on farms (Hagevoort et al., 2013; Daigle and Ridge, 2018). Although scientific tools such as science-based strategies, best management practices, and audits/assessments are essential for identifying and managing the factors that pose risks to animal welfare, the understanding of challenges and lack of metrics related to worker welfare is as essential for dairy cattle welfare.

Conclusion

Animal welfare is a continuously evolving issue, yet a topic that resonates strongly with the general public and all stakeholders of the dairy supply chain. In order for the dairy industry to position itself as a trailblazer in animal welfare, leadership is needed across the industry to drive advancements in understanding and adopting welfare standards, demonstrate shared values and compliance with accepted standards, and foster new ways of collaborating together as an industry. Furthermore, new methods of addressing cattle welfare-related issues may require a shift in farm leadership skills, approach, or training, because the industry must focus efforts on its people as part of its focus on animals. Given the increased need and dependency of a skilled and stable workforce to carry out cattle management needs in dairies, new tools must account for the physical and mental well-being of owners, managers, and hired labor of dairies.

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Maximizing Whole Farm Feed Efficiency

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Maximizing Whole Farm Feed Efficiency

Four-State Dairy Nutrition & Management Conference

Elanco

June 12, 2019
Dubuque, IA

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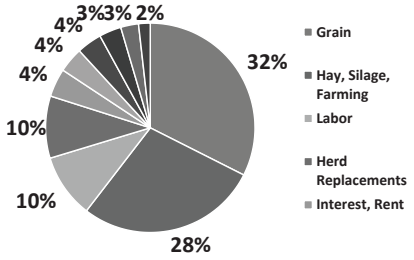
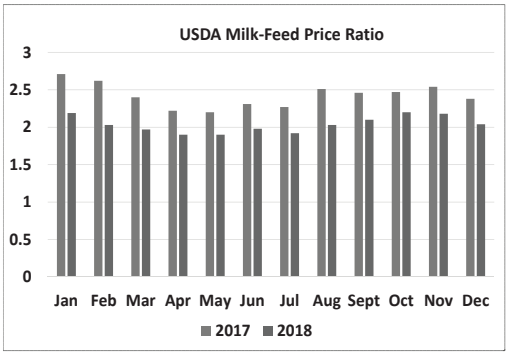
Feed Cost vs Feed Efficiency

	Daily Milk Production/c, lbs				
	80	85	90	95	100
Daily Feed cost/c @$8.50/cwt	$6.80	$7.23	$7.65	$8.08	$8.50
Increased Daily Feed Cost vs base, $		$0.43	$0.85	$1.28	$1.70
Estimated Daily Feed Cost vs Base, $		$0.26	$0.52	$0.78	$1.04
Potential Daily Difference, $		$0.17	$0.33	$0.49	$0.66
Potential Daily Feed Cost/c		$7.06	$7.32	$7.58	$7.84
Estimated Feed Cost/cwt		$8.31	$8.13	$7.98	$7.84

2017 Percentage of Total Cost of Dairy Production



Genske, Molder Company

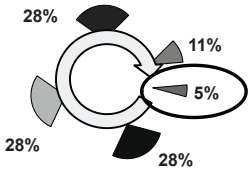


Thoughts to Consider

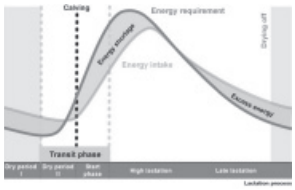
- Efficient use of feedstuffs
  - Measured?
    - Dairy or whole farm
    - Per unit of milk, cow, total cost
    - Financial impact
  - Accounting for feedstuff loss
    - Physical
    - Financial
- Economic opportunity?

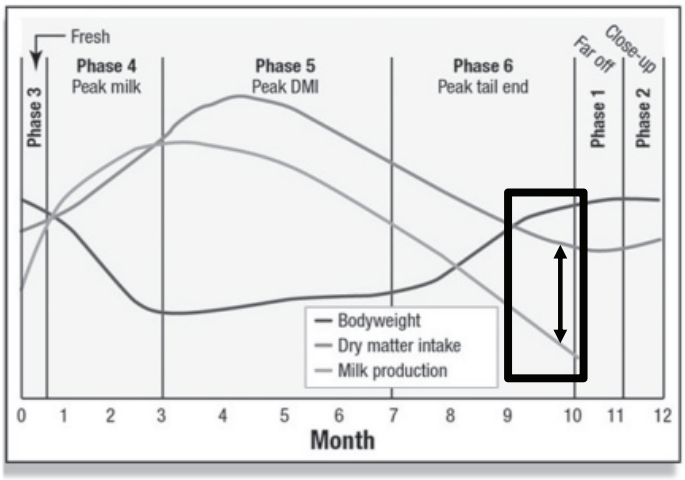
First Things First

- Production Cycle
  - Transition
    - 3 wks pre-calving
    - 3 wks post-calving



- Reproduction
  - Days in Milk
  - Pregnancy Rates





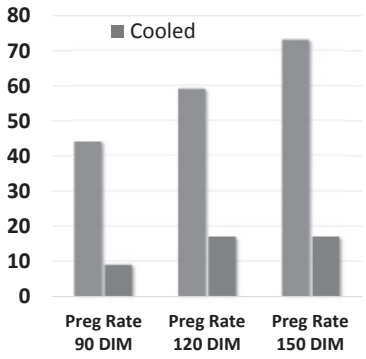
Source: Dr. Mike Hutjens, University of Illinois, Extension Dairy Specialist

Pregnancy Rates of Cooled and Non-Cooled Cows

Cooled cows = <102.2ºF (39ºC) Body Temperature

Non-Cooled Cows > 103.1ºF (39.5ºC) Body Temperature

Flamenbaum, 2012



Focus

- **Pre-Fresh**
  - Health Start
  - Cow Comfort
  - Absence of Metabolic Disease
- **Early Lactation – 150 DIM**
  - Peak Milk
    - 1 pound Peak = 250 – 300 pounds on lactation
  - Intake
    - 1 pound increased DMI = 2.5 to 3 pounds of milk
  - Cow Comfort
  - Cow Health
  - Reproduction

Impact on Dry Cow Cooling

Summary of current research on the influence of dry cow cooling on milk yield (lb/d).

Study	Method	Milk (lb/d) of cows not cooled	Milk (lb/d) of cows cooled
Avendaño-Reyes et al., 2006 (Mexico; 56 DIM)	Fans and water spray (mist ring)	55.9[a]	71.5
Urdaz et al., 2006 (CA; 60 DIM)	Add fans/shades to sprinklers over feed bunk	84.9[c]	88
do Amaral et al., 2008 (FL; 42 DIM)	Fans and sprinklers	55.9[c]	73.0
do Amaral et al., 2009 (FL; 140 DIM)	Fans and sprinklers	67.8[b]	78.3
Adin et al., 2009 (Israel; 90 DIM)	Fans and foggers along feed bunk	86.2[c]	90.9
Tao et al., 2010 (FL; 147 DIM)	Fans and sprinklers	69.5[b]	80.3

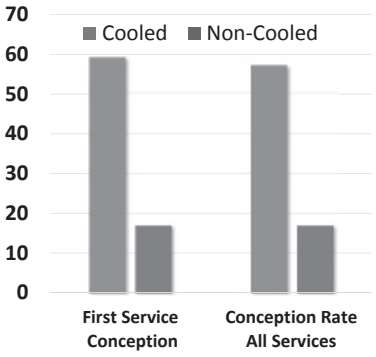
[a]$P \leq 0.15$, [b]$P \leq 0.10$, [c]$P \leq 0.05$

Conception Rates of Cooled and Non-Cooled Cows

Cooled cows = <102.2ºF (39ºC) Body Temperature

Non-Cooled Cows > 103.1ºF (39.5ºC) Body Temperature

Flamenbaum, 2012



Effect of Pre-Fresh Cow Cooling

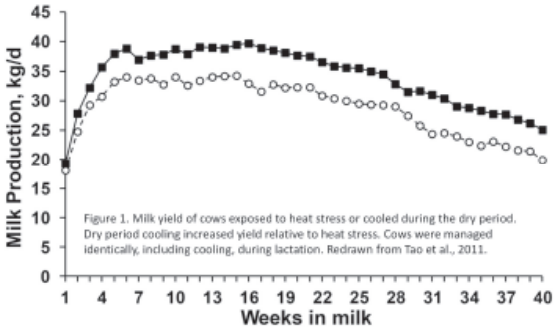


Figure 1. Milk yield of cows exposed to heat stress or cooled during the dry period. Dry period cooling increased yield relative to heat stress. Cows were managed identically, including cooling, during lactation. Redrawn from Tao et al., 2011.

Dry Cow Cooling

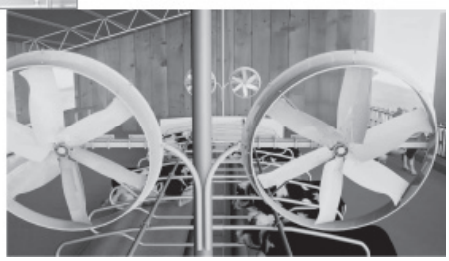
- **Missed Opportunity**
- **Relatively Inexpensive to Install**
- **Heat Stress Months 4-5**
- **Track Success of Cows Dry June – August**
- **Track Success of Cows Calving June - September**

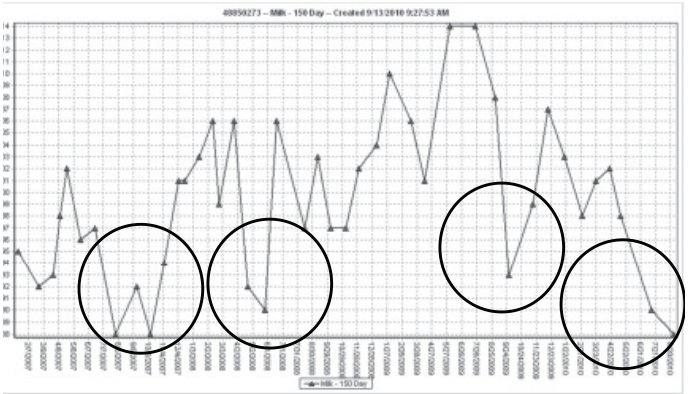
Increased CBT

- Milk production drops when rectal temps exceed 39°C (102.2F) for more than 16 h (Igono and Johnson, 1990)
- Milk yield declines 1.8 kg for each .55°C increase in CBT above 38.9°C (Johnson, 1963)
  - 39°C→39.5°C = drop of 1.8 kg or 4 lbs. of milk

Additional Transition Considerations

- **Feed Additives**
  - Monensin
  - B-Vitamins
    - Choline
    - Niacin

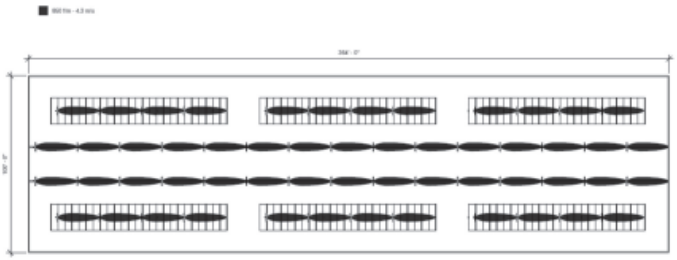




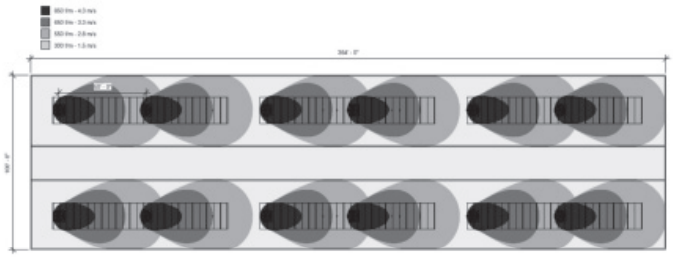
15 to 25 pound drop each summer !!!!

$2.40 to $4.00/c/d

Air flow pattern from 36” fans mounted every 24 ft



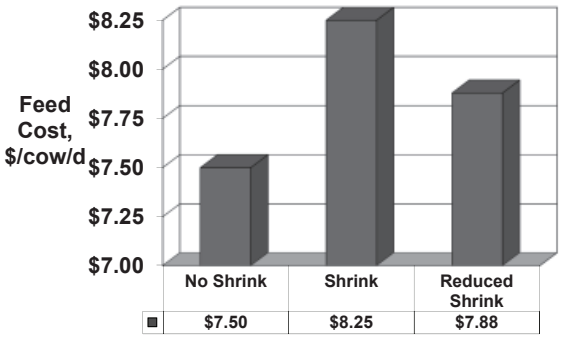
Air flow pattern from 72" fans (ECVC) mounted every 50 ft



How to Make $50,000

- Increase milk price
  - 500 cows @ 85 lb/cow = $0.32/cwt
- Increase milk production
  - 500 cows @ $16/cwt = 3.2 lbs/cow daily
- Reduce feed shrink
  - 4% @ $7.50 daily feed cost

Real Feed Cost



Can You Measure True Feed Cost?

- Shrink -
  - Amount Delivered
  - Amount Fed
  - Difference is Shrink
- Factors
  - Moisture
  - Spoilage
  - Losses
    - Wind
    - Animals

What Can't Be Measured Can't Be Managed!!!!!!

Herd Size	Annual loss @ $7.50 Feed Cost /cow daily		
	8%	10%	12%
500	$ 109,500	$ 136,875	$ 164,250
1,000	$ 219,000	$ 273,750	$ 328,500
1,500	$ 328,500	$ 410,625	$ 492,750
2,000	$ 438,000	$ 547,500	$ 657,000

Ingredient	Herds	Range, %	Weighted mean, %
Corn Silage (Pile or Pit)	15	4.8 – 16.0	9.1
Corn Silage (Bag)	8	6.5 – 14.0	9.9
Haylage (Pile or Pit	12	5.6 – 16.0	10.2
Haylage (Bag)	11	8.5 – 17.0	10.7
Bulky Ingredients	14	3.5 – 14.0	11.3
Wet Byproducts	13	12.0 – 40.0	23.0
Bagged Ingredients	16	2.0 – 19.0	8.1

Greene, 2014

Storage Type	Herds	Range, %	Weighted mean, %
Feed Center (3-Sided)	16	2.5 – 11.0	6.7
Feed Center (Enclosed)	5	2.0 – 7.0	4.0
Upright/Over-head Storage	7	2.0 – 7.0	4.0

Greene, 2014

Where is the Shrink on Your Farms?

Example of Shrink in a Commodity Barn

- **Dry Distillers**
  - 8.4%
- **Canola Meal**
  - 3.5%
- **Whole Cotton Seed**
  - 5.2%
- **Mineral**
  - 1.6%
- **Flaked Corn**
  - 2.7%

$0.13/c/day

4,500 cows

$213,525/yr

Attitudes on Shrink Control

- **Lack of Data**
  - **"Can't Manage What You Can't Measure"**
- **Cost of Doing Business**
- **Out of Sight Out of Mind**
- **Not Worth My Time**
- **Potential Profit Opportunity**

Hay Bales
Roll Tarps
Brooms

Reduced
Shrink
Initial Cost
Inventory

500 Cow Dairy

Annual Savings
32.5 tons SBM =
$12,350

20 minutes/load
4 hr/d or
1,460hr/year
$73,000/yr

Feed Centers

- **Reduced Shrink**
  - **< 2%**
- **Increased Material Handling Efficiency**
- **Reduction in Feeding Time**
- **Reduction in Energy Consumption**
- **Payback Opportunity**

Cost of Delivery Error

	Deviation Wt, lb	Cost/lb,$	Cost/Mix $
Corn Silage	120	0.025	3.00
Alfalfa Hay	90	0.125	11.25
Corn	20	0.071	1.42
SBM	20	0.20	4.00
Premix	30	0.45	13.50
Molasses	20	0.060	1.20

$0.229 cow/day **$83,634** 1000 cows/year **$34.37**

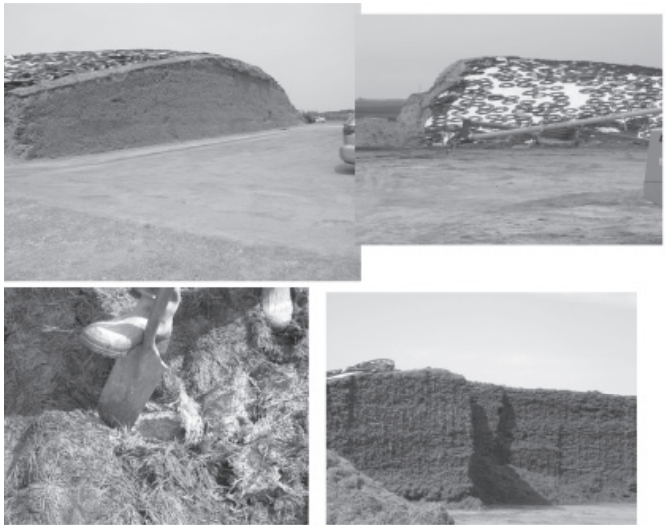
Improving Feeder Accuracy

- Tracking program
- DM of wet feeds
- Premix – small inclusion - 5lb/head
- Loader bucket size
- Regular review of data

Feed Delivery Errors

	Target Wt, lb	Loaded Wt, lb	Deviation Wt, lb	% Error
Corn Silage	9,000	9,120	120	1.3
Alfalfa Hay	3,200	3,290	90	**2.8**
Corn	2,000	2,020	20	1.0
SBM	800	820	20	**2.5**
Premix	400	430	30	**7.5**
Molasses	100	120	20	**20.0**

150 Cow Mix



What is Your Silage Storage Loss?

- Fermentation – **6% of DM**
- Seepage – **1% of DM**
- Surface – **up to 50% of DM**
- Feedout – **5 - 15% of DM**
- Type of Storage
  - Bags – 10 - 12%
  - Bunkers – 15 - 20%
  - Piles – 15 - 25%
  - Towers – 10 - 12%

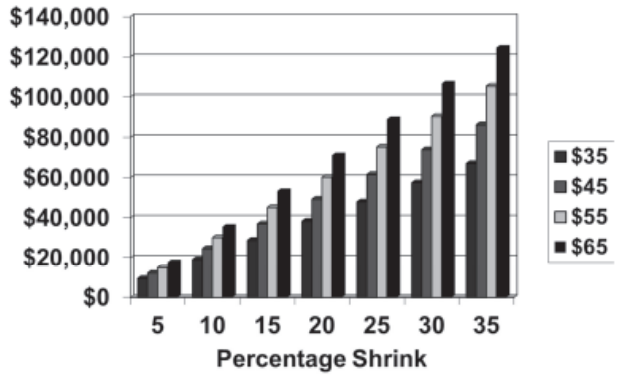
Impact of Feeding Spoiled Silage to Steers

Item	0% Spoiled	25% Spoiled	50% Spoiled	75% Spoiled
Intake, lb	17.5	16.2	15.3	14.7
% Reduction		7.4	12.6	16.0
NDF Digestibility, %	63.0	59.5	56.0	51.0

7% Decrease in DMI = **3.5 lb of DMI = 10.5 lb of milk**

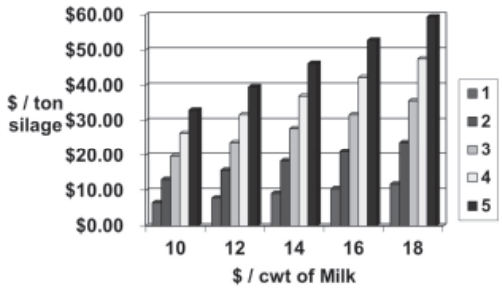
Bolsen, 2004

Annual Cost of Silage Loss
1,000 Cows fed 30lb/c/d of silage



Additional Benefits

- Reduced loss = Increased Forage Quality
  - *30 lb feeding rate* *66 cows/ton*



Tons and Acres Required for Annual Silage Shrink

Amount of Shrink, %

	5	10	15	20	25	30	35
Extra Tons	274	548	821	1,095	1,369	1,643	1,916
Extra Acres	9.1	18.3	27.4	36.5	45.6	54.8	63.9

1,000 cows fed 30 lbs silage per day
Acres estimated based on a yield of 30 ton/acre

Silage Management

- **Reduced Losses of DM and Nutrients!!**
  - Can you measure this?
- **Reduce Secondary Fermentation**
  - Silo Face Size
  - Face Management
  - Packing and Covering
- **Improve Milk Production**
- **Reduce Feed Cost per cwt of Milk**

Keys to Silage Success

- Silo Sizing and Selection
- Hybrid Selection
- Harvest Moisture
- Harvest Quickly
- Inoculants
- Packing Density
- Covering
- Feeding Management

Quotes from John Wooden

- **"Do not let what you cannot do interfere with what you can do."**
- **"It's the little details that are vital. Little things make big things happen."**
- **"Failing to prepare is preparing to fail."**
- **"Failure is not fatal, but failure to change might be."**
- **"Make each day your masterpiece."**

Whole Farm Efficiency

- Take the Right Measurements
- Utilize the Data
- Focus on the Right Things
  - Cows
  - Forages
  - Cow Comfort
- Be Consistent
- Involve the Whole Team

How to Survive Tough Economic Times

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It certainly goes without say that the last 4 ½ years have been the most trying times in the business of milking cows. Many farmers remember 2009 as a very difficult year. However, it was only one year then margins got better. The landscape of the industry going forward will continue to consolidate and look much different. It appears a $15 to $17 milk price may be the range dairy farmers may have to live with.

If points in time can be marked which accelerated the new unknown period, it began with the elimination of the EU milk quota which unleashed the production of 23 million dairy cows to the world market 2015. Followed by the implementation of the Canadian Class 7 milk policy in February of 2017 which closed the door on the shipping condensed milk from the US to Canada. Many dairy farms in Wisconsin and New York found themselves scrambling for a place to go with their milk.

US milk plants now found their capacity to process milk at a maximum level. Between a worldwide abundance of milk and US manufactures unable to handle more raw milk the farm mailbox price of milk remained under the cost of producing it for 80% of dairy farmers.

The purpose of this paper is to outline how to survive and continue to operate a dairy farm in difficult and tough times. These comments will mirror many of the strategies that the top 20% of dairy producers do to obtain a profitable bottom line when others find it difficult to make ends meet. There are 100 difference things successful dairy farmers do every day. This paper highlights some of those key items.

1. The starting point always must be to have a thorough understanding of the total financial picture of the dairy. In the past working hard by taking care of the cows and growing crops was mostly all that mattered. Today, working hard continues alongside of thinking hard. Getting the financials in order first, then discussing the numbers, thinking through the numbers and planning must take place before decisions are made. Financial items needed are as follows:
   a. Yearend Balance Sheets must be accurately completed with detailed numbers.
   b. A 3-year Income Statement must show Accrual adjusted figures.
   c. A projected Cash Flow must be done before the end of the current year or shortly after the new year begins.
   d. A written business plan must reflect the projected Cash Flow.
   e. The projected Cash Flow and Business Plan is reviewed quarterly at team meetings with the family, key employees that need to know, lender, veterinarian and other professionals when input is necessary.

2. Key Ratios are calculated and monitored to achieve the following ranges:
   a. Ownership Equity +50%
   b. Current Ratio 2:1
   c. Term-debt and Lease repayment ratio 1.5
   d. Principal and Interest as a % of Gross Income 15%
   e. Debt/Cow $5,000
   f. Debt/CWT Milk $15
   g. Debt to Revenue 1:1
   h. Operation Expense as a % of Gross Income 70%
   i. Feed Cost as a % of Gross Income 20% to 45% (depends on growing or buying forage)
   j. Feed and Cropping Cost as a % of Gross Income 20% to 45% (see h)
   k. Cost of Producing 100 Pounds of Milk $15 - $17

3. Communicating with your primary lender is more important than ever. Banks are facing mergers and acquisitions (M&A). The Farm Credit system has gone through consolidations. Each time there is a change in ownership or management the personal relationship with a lender is at risk. Generally, the loan officer is the link between the lender and the farm. If a change occurs at the lender the long-time relationship may change as well. The regulators of all lenders are becoming more stringent regarding the auditing of dairy farm loans. The tougher rules will boil down to the farm level. If the lender seems to becoming more difficult it may be the regulator that is adding to the mix. It will be more important in the future to survive by having an open communication with the lender. It is equally important to have a thorough understanding of all of the financial information on point #1 so your lender knows you know.

4. Milk Marketing and utilizing government milk marketing opportunities: Taking a position with a broker on a portion of milk can make the overall monthly income look more positive in tough times. A thorough understanding of the mechanisms and tools must be gained though education. A number of government milk programs have come into existence. They are not the total answer to low milk prices however they can add to the farm's income. Once again educating oneself is the key to understanding. The USDA FSA office personnel in many cases can be a big help in this area as well.

5. 100,000 SCC along with 6-7 pounds of components are going to be keys in selling milk in the future. Regardless of the milk plant, indirectly consumers will demand to know that their milk comes from farms with high standards. It is also important to get on the list of a High Paying Milk Plant. Some milk plants are selling high quality end products at a premium price. These same plants are paying additional premiums for the raw milk they take in. In tough times a dollar or two dollars over what others are being paid goes a long way toward profitability. It is important to let high paying milk plants know who you are.

6. SOP or Standard Operating Procedures are another way to help farms stay profitable in tough times. The SOP are a proper and approved way to do certain jobs on a farm as "effectively" as possible. They lay out the proper way to assist a cow during calving. There is a step by step check lists of how to care for a calf when it is born. Care of the dairy cows 30 days before calving and 30 days after have specific actions. There are SOPs for each job on the farm. This way there are no assumptions made that everyone should know how to do a job. SOP are in writing. Training and follow up is practiced daily.

7. Vision and Mission statements are real documents that hang where owners and employees can see them daily. The statements are short, clear and meaningful. Written in two languages.

8. Cow comfort is always at the top of everyone's mind each day. Top Dairy Producers question cow comfort and ask themselves every morning as they walk up to the dairy, "What can be done better to make the cows more comfortable?" Is the milking parlor comfortable for the cows as well as for the milkers? Is the holding area kept cool until the last cow enters the parlor? Do cows have plenty of water to drink as they return to the free stall? Is there fresh feed waiting for the returning cows? Are the stalls large enough? Does the bedding material keep the cows in their stalls for 10 to 12 hours a day? Are there enough stalls?

9. Producing more milk is a goal of dairy producers that survive. They understand at times there is a worldwide glut of milk. However, they think about their "Barnyard" and what they need to do to be profitable. Their cows produce 1,500 more pounds of milk every year. Breeding programs select productive sires. Some use genomic testing and use the information to select the youngstock that will lead their herds in the future.

10. Forage programs are outlined in the winter months. There are team meetings with crop consultants, nutritionist, lenders and veterinarians. Seeds are selected, planting times and harvest times are set. Custom operators and manure custom operators join the meetings at times to learn what is expected of them and the importance of the timing of their work.

11. Enterprising is done to know the true costs of certain areas of the dairy. The true costs of producing forage is divided out from other expenses. Seeds, rent, the costs of owning land, tillage, spraying, harvest, trucking, inoculating, packing, and labor are all factored in. The costs of renting or owning machinery is separated out including functional depreciation. Joint ownership of some pieces of equipment may make sense to some.

12. Evaluating the cost of raising heifers is kept separate. Evaluations are made regarding where the youngstock should be reared. Housing near the dairy? Raised by a local heifer grower or animals sent away at 3 days of age to a western climate. Getting the right size and correctly raised animals returning to the dairy is critical. With the costs of raising heifers, surviving farm strategies grow only the heifers they need. Older cows that are paid for and have 1 or 2 more years of productive life are kept longer. Older cows will produce 20 to 30 pounds more milk than a first calf heifer. The number of incoming heifer are at the right number so there is no reason to force older productive cows out of the barns. Some cows and heifers are bred to beef bulls to limit the number of replacement heifers. The beef crosses are commanding a higher calf price currently. Future markets will determine if this strategy will continue.

13. Other diverse enterprises are considered. Further processing of milk in a partner owned plant may

be considered by some. The list of other types of enterprises are many in light of the concentrated business of milking cows. Owning a shared “Feed Facility” where 3 farms deliver and truck TMRs from may be considered. A great deal of research and number crunching must be completed before money is spent on a new enterprise.

14. Transition planning is at some point in an ongoing process. As the balance sheets continue to grow the zeros add up behind the numbers. Partial or total farm transfers take 10 years or more to achieve. Transfers may be with blood relatives or those outside of the family. Professional consultants, accountants and attorneys are always involved in the process.

15. Those that survive tough economic times see their dairy as the Business of Milking Cows. It is a “Business” and needs to be operated that way!

Feeding Options with Todays Economics

Dr. Mike Hutjens
University of Illinois, Emeritus

Feeding Options With Today's Economics

Four State Dairy and Management Conference
June 14, 2019

Mike Hutjens
University of Illinois, Emeritus

ILLINOIS

Holstein Component Profile by Days in Milk and Lactation Number

Lact #	Milk (lbs)	Fat % 1-40	Fat % 41-100	Fat % 101-199	Fat % 200-305	Fat/Prot 1- 40	Protein % 1-40	Protein % 41-100	Protein % 101-199	Protein % 200-305	Milk (kg)
1	19,000	2.9%	3.0%	3.5%	3.7%	1.32	2.2%	2.4%	2.8%	3.0%	8,618
	23,000	3.4%	3.3%	3.6%	3.8%	1.36	2.5%	2.6%	3.0%	3.1%	10,433
	26,000	3.8%	3.5%	3.6%	3.9%	1.36	2.8%	2.8%	3.0%	3.2%	11,793
	30,000	3.9%	3.5%	3.6%	3.8%	1.34	2.9%	2.8%	3.0%	3.2%	13,608
2	19,000	2.9%	3.1%	3.5%	3.7%	1.26	2.3%	2.5%	2.9%	3.1%	8,618
	23,000	3.3%	3.3%	3.6%	3.8%	1.32	2.5%	2.6%	3.0%	3.2%	10,433
	26,000	3.7%	3.4%	3.6%	3.8%	1.32	2.8%	2.8%	3.0%	3.2%	11,793
	30,000	3.8%	3.4%	3.5%	3.8%	1.31	2.9%	2.8%	3.0%	3.2%	13,608
3+	19,000	3.5%	3.4%	3.6%	3.8%	1.35	2.6%	2.6%	2.9%	3.1%	8,618
	23,000	3.7%	3.4%	3.6%	3.8%	1.37	2.7%	2.7%	3.0%	3.2%	10,433
	26,000	3.9%	3.4%	3.6%	3.8%	1.39	2.8%	2.7%	3.0%	3.2%	11,793
	30,000	4.0%	3.4%	3.5%	3.7%	1.38	2.9%	2.8%	3.0%	3.2%	13,608

* 19,000 RHA n=1,014 herds, 23,000 RHA n=1,998 herds; 27,000 RHA n=1,022; 30,000 RHA n=292 herds

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Finding 65 cents per 100 pounds of milk

- Genske, Mulder & Co Certified Public Accountants
- First nine months of 2018
  - Arizona: -15.2% margin; loss of $1.3 million
  - Upper Midwest: -11.4% margin, loss of $781,761
  - Northeast: -21.4% margin; loss of $803,243

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Option 2: Marginal Dry Matter Intake

- Last pound of dry matter consumed can support two plus pounds of milk
- A pound of dry matter costs 10 cents
- Two pounds of milk worth 30 cents at 15 cents a pound
- Profit is **20 cents** per pound of dry matter or per cow per day

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Option 1: Building Your Milk Check

- Improving milk components
  - Milk fat is valued at $2.51 per pound
  - Milk protein is valued at $1.14 per pound
- Fat test increase of 0.2 point (3.7 to 3.8) leads to 0.1 pounds more milk fat times $2.51 leads 25 cents per cwt or **20 cents** per cow per day at 80 pounds of milk

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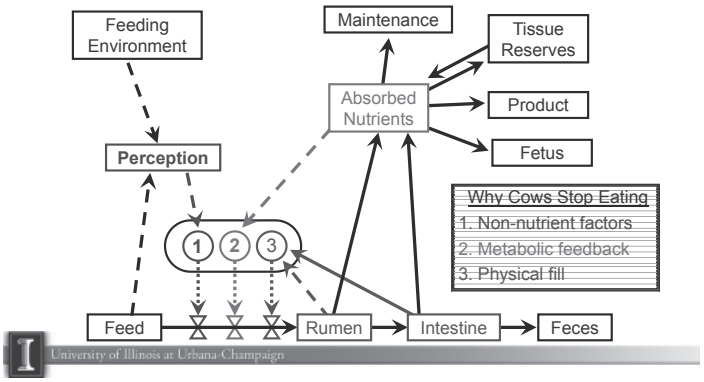

Milk Fat and Milk Protein Relationship

(Hoard's Dairyman—August 2018)

	Fat %	Protein %	Protein vs Fat	Fat vs Protein
Ayrshire	3.89	3.14	81%	1.23
Brown Swiss	4.05	3.32	82%	1.22
Guernsey	4.56	3.35	73%	1.36
Holstein	3.81	3.06	80%	1.24
Jersey	4.89	3.70	75%	1.32

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2018 U.S. Feed Additive Use

2018 Hoard's Market Survey

Buffers	38
Yeast/yeast culture	29
Rumensin	24
Mycotoxin binders	24
Probiotics	11
Niacin	10
Omnigen	8
Don't use	7
Feed bunk stabilizer	2

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Benefit to Cost Ratios

Buffers	8 : 1
Biotin	7 : 1
Yeast products	5 : 1
Ionophores	5 : 1
Silage inoculant	3 : 1
Rumen protect choline	3 : 1

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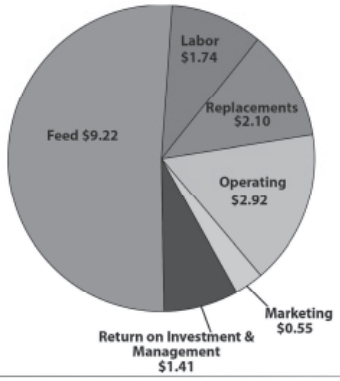
Cost Comparison Summary

(Cost per cwt)



University of Illinois at Urbana-Champaign

Additives Recommended for Lactating Cows

- Rumen buffers– **save 6 cents per cow**
- Yeast culture/yeast **products—save five cents per cow**
- Monensin (Rumensin)—**save 3 cents per cow**
- Silage inoculants—**save 3 cents per cow**
- Biotin—**save 4 cents per cow**
- Organic trace minerals—**save 10 cents per day**

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Twenty Percent Extra Heifers on Farm

- California data: Cost is $2.10 per cwt of milk
- Assume the 20% value is on your farm
- 20% of $2.10 is 42 cents a day

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Hutjens Priority

1. Rumensin
2. Silage inoculants
3. Organic trace minerals (Zn, Se, Cr, & Cu)
4. Yeast and yeast culture
5. Sodium bicarb/S-carb
6. Biotin

Rumen impact

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Raising Heifers is Not a Profit Center

Cost to raise heifers is >$2,000 than current market prices

- Number of heifers needed:
  - Culling rate
  - Death losses of heifers
  - Calving interval
- Tools:
  - Genomics (find the best ones)
  - Sex semen (get heifers from the best genetics)
  - Beef crossbreeds (premium +$150, calving ease, and healthy of calves)

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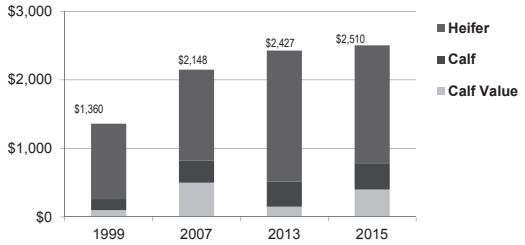
Total Cost to Raise a Dairy Replacement from Birth to Freshening



NDFD: An Index of Dry Matter Intake

One unit change in NDFD equals

- **0.26 lb. of Dry Matter Intake**
- **0.47 lb. of Fat Corrected Milk**

Increase Forage NDFD Two Units

- Total forage program increased from 55 to 57 percent
- May lead to 0.94 pounds more milk
- Added income is **15 cents per day**

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Defining Shrink

- **The quantity of feed fed that the cow doesn't eat**
- **Varies from 1 to > 20% of available feed**
- **Cost 10 cents to 15 cents per cow per day**

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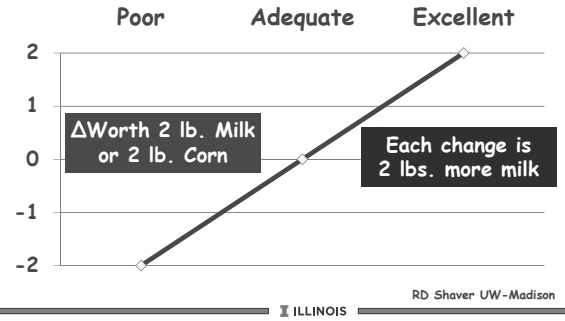
Kernel Processing Score



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Shrink Areas of Focus

- Forage management
- Pre-blending concentrates
- Weigh backs
- Reducing feed variation
- TMR mixing strategies (precision blending)
- Storage (bags, vertical storage, etc)
- Tracking inventory

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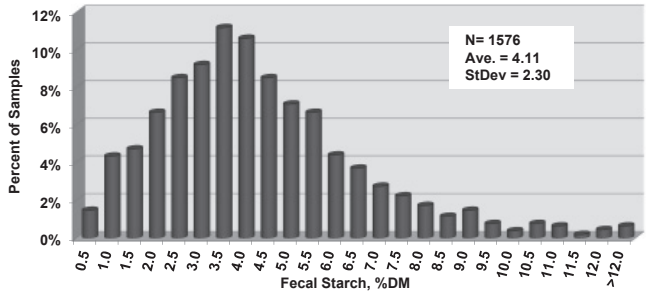
(CVAS, 2017)



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Weigh Back Considerations

- **1-2% of total dry matter offered (steers 1st choice)**
- **> 5% weigh backs must go to cows**
- **50% of feed available at each feeding with 2x delivery**
- **Evaluate sorting (+/- 5% each box)**
- **Remove each day (each feeding)**
- **Feed costs savings: 50 lb DMI times 2% equal 1 pound DM or 10 cents per cow**

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Change Kernel Processing Score

- Shift from 61 to 71 score results in two pounds more milk
- Results in **32 cents** per cow per day
- Lower fecal starch from 7 percent to 5 percent leads to 1.3 pounds of milk
- Results in **20 cents** more per cow
- These values could overlap

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Grouping Systems increase IOFC

1. **Fresh (3wk) vs. all other cows**
   - Fresh diet can be very expensive
   - May have carry over effects
   - May increase peaks
2. **Two year old vs. older cows**
   - Diets can be identical
   - Increase production of 2 yr olds

Many Grouping Systems increase IOFC

3. Group by production
   - Diets formulated for each group
   - Targeted use of additives
   - Forage quality inventory management

Comparing Ration Costs with Various Forage Programs

- Used the 2018 forage costs (purchase/market prices)
- Rations balanced for energy, RDP, RUP, and fiber
- Milk yield was 70 pounds of milk
- No minerals, vitamins, or additives were added or balanced

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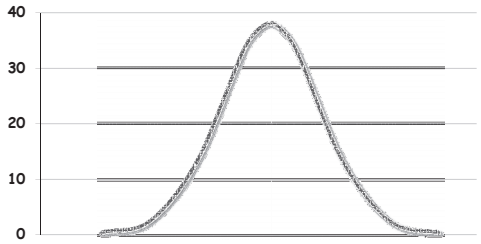
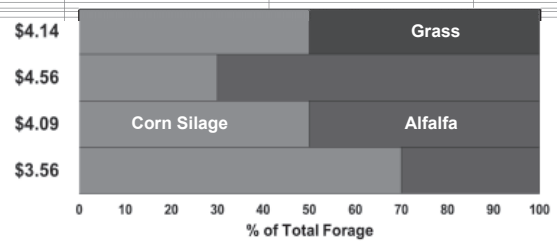
Grouping by Production (80 lb average)



1 average with large variation

Economics of Forage Feed Costs Per Day (70 pounds of milk, 2018 Feed Prices)



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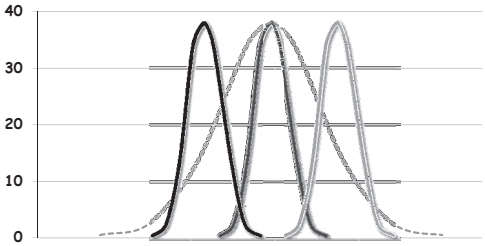
Grouping by Production



- 3 different means
- Smaller SD within pens

Feed Benchmarks 2019

Feed costs per cow per day	$5.01
Feed cost per lb DM	$0.10

	Milk Production	
	80 lb	70 lb
Feed cost per cwt milk	$6.26	$7.16
Income over feed costs / cow ($16)	$9.74	$8.84
Feed efficiency (kg milk/kg DM)	1.6	1.4

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Formulating for Groups

1 group (mean = 75 lbs, SD = 13)
Protein for 75 + 13 = **88 lbs**

3 groups

Low (mean=60 lbs, SD = 4)
MP for **64 lbs**

Mids (mean = 75 lbs, SD =5)
MP for **80 lbs**

Highs (mean = 90 lbs, SD =6)
MP for **96 lbs**

Avg = 80 lbs

Economics of Feed Efficiency

(70 lb milk, 10 cent lb DM)

Feed efficiency (lb milk/lb DM)	DMI (lb/day)	Difference (savings/day)
1.40	50.0	
		$0.34
1.50	46.6	
		$0.28
1.60	43.8	

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Milk Yield Targets (Ohio State University)

Milk Yield (lb)	Feed efficiency
60	1.32
65	1.38
70	1.44
75	1.49
80	1.54
85	1.58
90	1.63

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Take Home Messages

- Can you find 65 cents per cow per day?
- A business focus on feed decisions
- Listen to your cows
- Use available tools to evaluate your feeding program

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Economics of Raising the Right Heifers

Albert De Vries
Department of Animal Sciences
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Economics of Raising the Right Heifers

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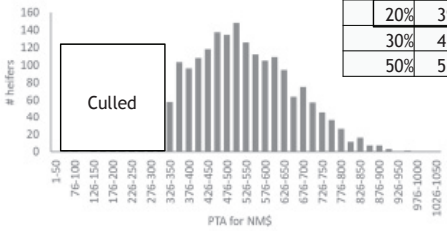
UF IFAS UNIVERSITY of FLORIDA

Four State Dairy Nutrition and Management Conference, Dubuque, IA. June 12-13, 2019

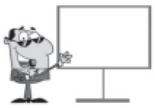
gPTA Net Merit Dollars for 2000 heifers

Culled	Min	Average	Gain	StDev
0%	69	512	0	145
10%	318	537	25	126
20%	391	564	52	112
30%	436	585	73	103
50%	510	631	119	88



Overview

1. Culling worst heifers
2. Make more dairy calves than needed? (keep best ones)
3. Keep best dairy calves or crossbred calf premiums?
4. Combining health, growth, genetics to predict first lactation IOFC



How much is +$52 PTA NM$ worth?

+$52 predicted transmitting ability / life time
= +$104 estimated breeding value / life time (= 3 years)
= +$34 estimated breeding value / year

Keeping the best 80% of heifers increases the genetic level of the herd by $34/cow/year
(but culling, discounting makes final value a little lower)

Top 50 Net Merit $

NAAB Code	Short Name	NMS	OR	Rel
29HO18960	ACURA *99-I	1065	G	74
200HO11500	MOSALAH	1056	G	73
551HO3600	NASHVILLE *99-I	1051	G	75
29HO18993	CRIMSON *99-I	1045	G	75
29HO18868	DIVERSITY *99-I	1041	G	74
614HO14226	ROME *99-I	1040	G	76
200HO11586	EINSTEIN	1040	G	73
29HO17454	INVICTUS *99-N	1039	G	73
551HO3800	DUBAI *99-I	1036	G	74
29HO18850	CELTIC *99-I	1035	G	73
551HO3797	TAMPA *99-N	1033		
29HO18937	BUNDLE *99-N	1032		
614HO14453	ARROWHEAD *99-I	1031		
614HO14065	SOLUTION *99-I	1030		
29HO18870	VENTURE *99-I	1030		
551HO3529	CHARL *99-I	1029		
29HO18906	BILLY *99-N	1029	G	74
7HO14703	HALLMARK *99-N	1024	G	74
29HO18929	VALUE *99-N	1022	G	76
551HO3590	DEDICATE *99-I	1017	G	77

Top 50 Cheese Merit $

NAAB Code	Short Name	CMS	OR	Rel
29HO18960	ACURA *99-I	1095	G	74
200HO11500	MOSALAH	1095	G	73
551HO3600	NASHVILLE *99-I	1098	G	75
200HO11586	EINSTEIN	1083	G	73
551HO3800	DUBAI *99-I	1081	G	74
29HO17454	INVICTUS *99-N	1081	G	73
614HO14226	ROME *99-I	1080	G	76
29HO18993	CRIMSON *99-I	1080	G	75
29HO18868	DIVERSITY *99-I	1079	G	74
29HO18937	BUNDLE *99-N	1077	G	74
7HO14703	HALLMARK *99-N	1064	G	74
551HO3749	MAROON	1061	G	74
29HO18784	AMPLIFY			
29HO18870	VENTURE			

Top 50 TPI

NAAB Code	Short Name	TPI	OR
200HO11586	EINSTEIN	2953	G
551HO3600	NASHVILLE *99-I	2932	G
551HO3800	DUBAI *99-I	2927	G
551HO3797	TAMPA *99-N	2919	G
551HO3812	IMPERIAL *99-I	2898	G
614HO14220	RIVETING *99-I	2896	G
29HO18960	ACURA *99-I	2895	G
200HO11500	MOSALAH	2895	G
200HO11330	MAESTRO	2889	G
551HO3590	DEDICATE *99-I	2879	G
614HO14065	SOLUTION *99-I	2870	G
1HO14107	MILLENIAL *99-I	2870	G

Net Merit $ = Predicted transmitting ability (PTA) of lifetime profit compared to profit of base cow

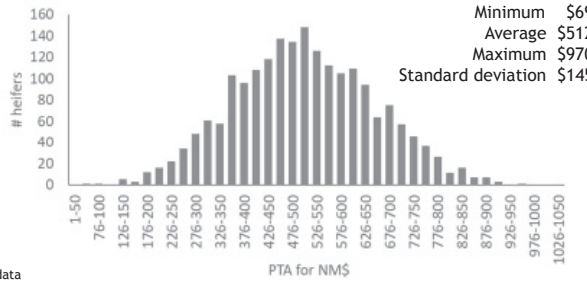
Hoard's Dairyman Bull List. Genomic Holsteins. April 2019

Make more dairy heifer calves than needed?

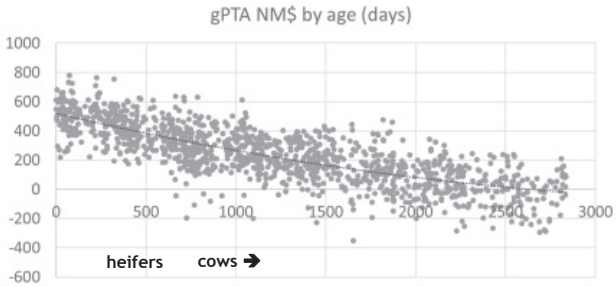
- Use sexed semen
- Higher selection intensity
- Greater selection gain
- Other advantages dairy calves

gPTA Net Merit Dollars for 2000 heifers

Minimum $69
Average $512
Maximum $970
Standard deviation $145

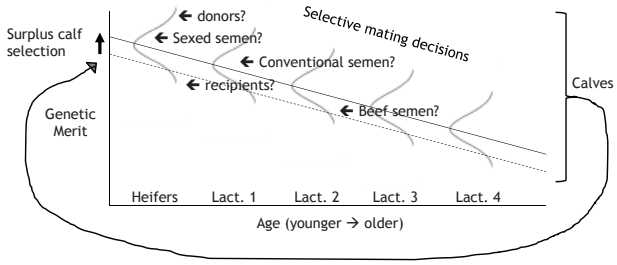


2013 data



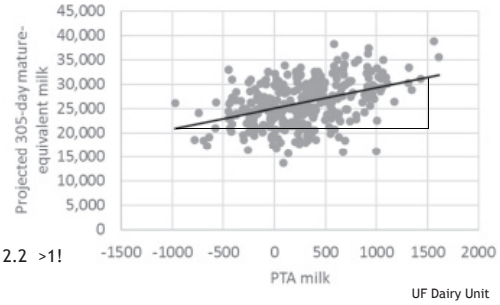
1,247 animals genomic tested at the UF Dairy Unit

Genetic model



Response to selection:

"Traditional" PTA milk of cow vs. phenotype mature equivalent milk of cow
Expected response to selection: 1 lb milk / 2 lb PTA = 1



Observed response to selection =

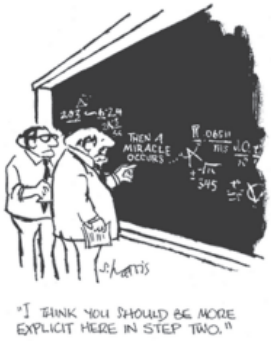
$$\frac{32{,}000 - 21{,}000}{(1{,}500 - -1{,}000) \times 2} = 2.2 \quad >1!$$

UF Dairy Unit

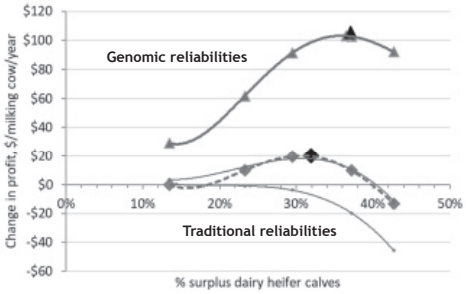
Herd budget model

Genetics, phenotype, prices, …
1000 milking cows

Bottom line:
Profit per milking cow per year



Response to selection = 2 x expected



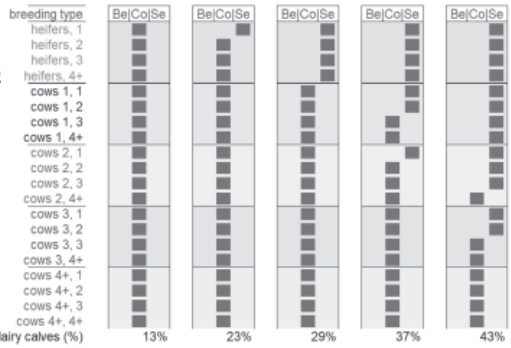
- 35% cull rate

0% → sexed semen use → a lot

0% → sexed semen use → a lot

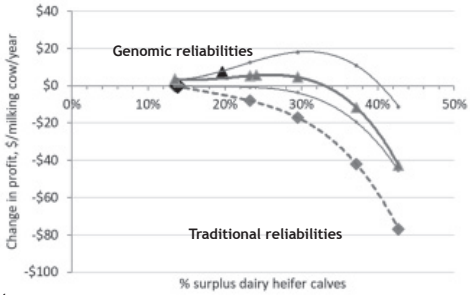
5 breeding policies

No selective mating



35% cow cull rate
Many other inputs
→ surplus calves

$100 lower dairy calf sale price compared to dairy bull calf



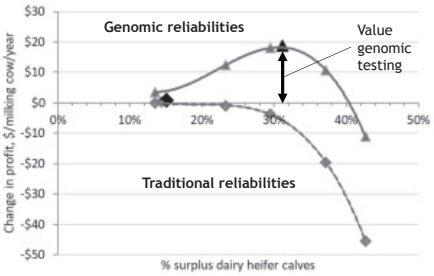
- 35% cull rate

0% → sexed semen use → a lot

Default = base line inputs

- 35% cull rate
- Vary use of sexed semen
- Complete budget of revenues and costs

- Conclusion: genomic testing pays if willing to make surplus heifers with lots of sexed semen



0% → sexed semen use → a lot

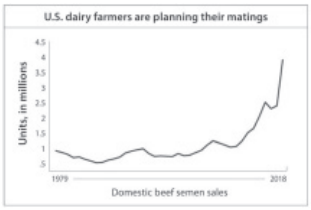
HOARD'S DAIRYMAN INTEL April 29 2019 08:05 AM

15

Beef-on-dairy semen sales skyrocketed in 2018

BY COREY GEIGER, MANAGING EDITOR

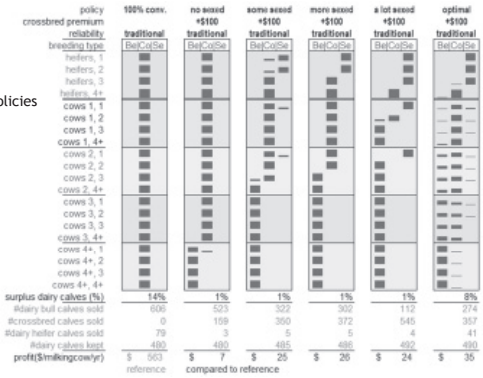
Crossbred premium
or
Dairy heifer calf selection?

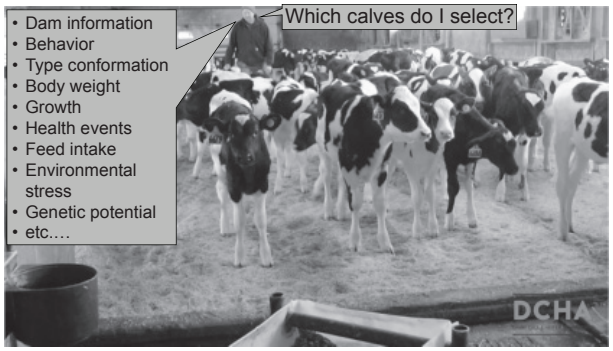


https://hoards.com/article-25428-beef-on-dairy-semen-sales-skyrocketed-in-2018.html

Scenario A

- 5 user-defined breeding policies
- 1 optimal breeding policy
- +$100 crossbred premium
- No genomic testing
- 35% cow cull rate

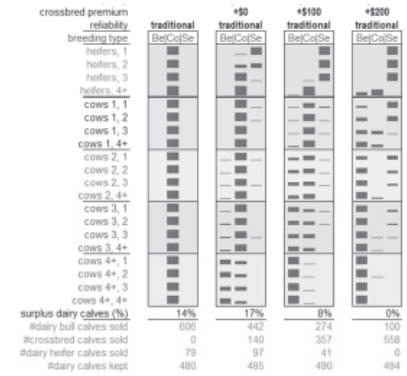




Michael Schmitt, Master's thesis, U of Florida (2019)

Scenario B

- 1 user-defined breeding policy
- 3 optimal breeding policies
- Increasing crossbred premium
- No genomic testing
- 35% cow cull rate

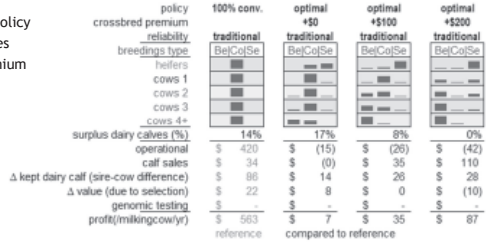


Questions

- Relative importance of health, growth, genetics on prediction of future milk production.
- How to best combine data sources: linear regression, random forest, gradient boosting
- Does it pay to wait and learn about calves (health, growth) and cull later?

Scenario B

- 1 user-defined breeding policy
- 3 optimal breeding policies
- Increasing crossbred premium
- No genomic testing
- 35% cow cull rate

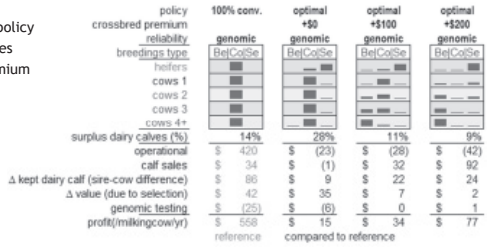


Calf selection: health growth genetics

- 12,000 calves born on a Florida dairy farm
- Born between 2009 to 2015
- Followed through first lactation
  - Survival and milk production
  - Information value = first lactation marginal milk income minus feed cost (IOFC)
- Data:
  - Health: diarrhea, respiratory, …
  - Growth: birth and weaning weights
  - Genetics: parent average, genomic test
- Combine data methods:
  - Regression, random forests, gradient boosting

Scenario C

- 1 user-defined breeding policy
- 3 optimal breeding policies
- Increasing crossbred premium
- With genomic testing
- 35% cow cull rate



Selection time point options: 3 datasets

Predictor groups

Phenotype (Pheno)

Predictor Variable	Variable Classes	Unit	Day First Available
ET	2	Category	Day 0
Weight birth		Pounds	Day 0
Weight120		Pounds	Day 120
Weight380		Pounds	Day 380
ADGto120		Lbs/day	Day 120
ADG120to380		Lbs/day	Day 380
ADGto380		Lbs/day	Day 380
RESP	5	# treat.	Day 120
DIGT	5	# treat.	Day 120
OTITIS	5	# treat.	Day 120
OTHER	5	# treat.	Day 120
ANY	5	# treat.	Day 120

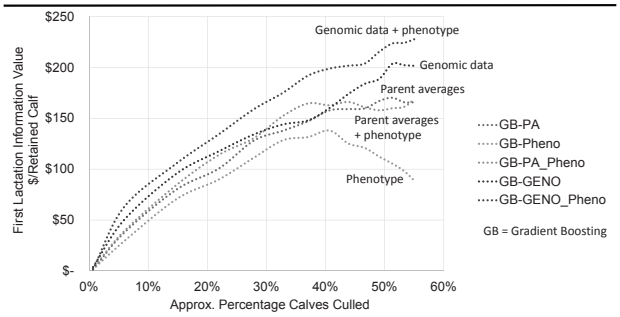
Parent Average (PA)

Predictor Variable	Unit	Day First Available
Fat.PA	Lbs/lact.	Day 0
Milk.PA	Lbs/lact.	Day 0
NetMerit.PA	Dollars	Day 0
Prot.PA	Lbs/lact.	Day 0

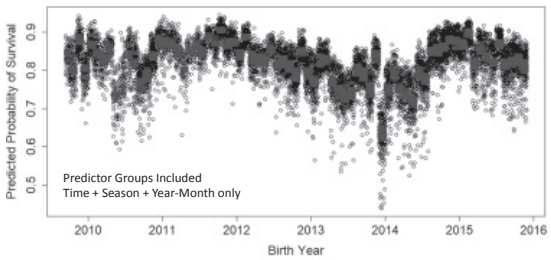
Genomic (GENO)

Predictor Variable	Unit	Day First Available
BWC.G	Composite	Day 120
CCR.G	Percentage	Day 120
DCE.G	Percentage	Day 120
DPR.G	Percentage	Day 120
DSB.G	Percentage	Day 120
Fat.G	Lbs/lact.	Day 120
FLC.G	Composite	Day 120
HCR.G	Percentage	Day 120
Milk.G	Lbs/lact.	Day 120
NetMerit.G	Dollars	Day 120
PL.G	Months	Day 120
Prot.G	Lbs/lact.	Day 120
PTAT.G	Composite	Day 120
SCE.G	Percentage	Day 120
SCS.G	Log	Day 120
SSB.G	Percentage	Day 120
UDC.G	Composite	Day 120
GnomcInbCo	Percentage	Day 120

First lactation IOFC for selection at day 120

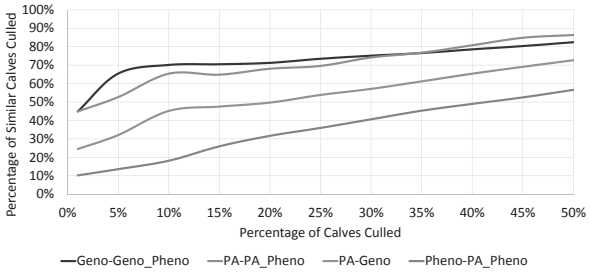


Survival probabilities to first calving

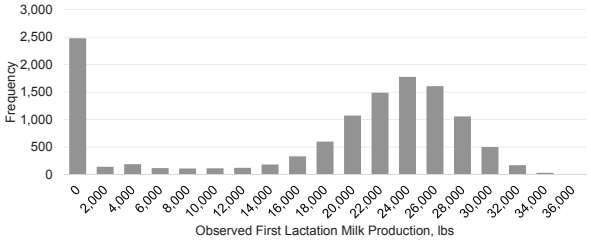


Different methods of ranking calves: different calves are culled

Day 120 - Gradient Boosting



Observed first lactation milk production until 305 days in first lactation (all calves)



n = 12,098

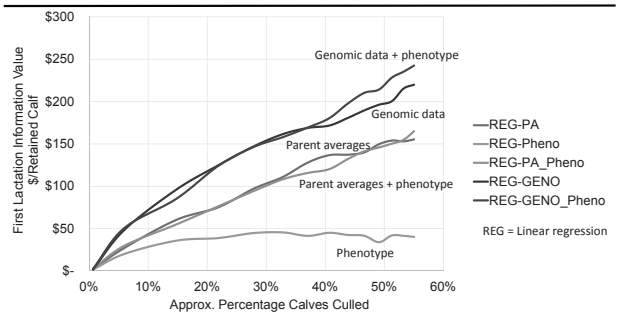
Summary: selection and breeding for heifers

1. Genomic testing is likely profitable when:
   - Make surplus dairy heifer calves (good reproduction, sexed semen)
   - Good response to genetics
2. Best breeding mix:
   - Combination of surplus dairy heifers calves + crossbred calves
   - Simple breeding mix almost as good as optimal breeding mix
3. Genetics data worth more than health and growth data

Thank you

devries@ufl.edu

First lactation IOFC for selection at day 120



Winding Meadows Dairy, Inc.

Terry Van Maanen
Rock Rapids, Iowa

Breeding

- Use sexed semen and beef bulls
  - Crossbred calves have more value in the marketplace
- Using sexed semen has made it difficult to get the right number of heifers
- Use beef semen on third breeding to get cows pregant

Dubuque, IA – June 12, 2019

Expanding from 1200 to 1600 cows

- Utilize double 20 parlor and labor efficiently
- Moved dry cows to home dairy

Dubuque, IA – June 12, 2019

Calf Raising

- Moved calves to Kansas Dairy Development
- Control death loss
- Calf rearing expense is $2.55 verses $3.60 per day
- Milder environment
- Manure dense neighborhood

Dubuque, IA – June 12, 2019

Management Team

- Using Genske, Mulder & Co. to review records
- Using financial consultant who understands dairy
  - Breeding costs
  - Forage costs need to be more accurate
  - Using Commodity & Ingredient Hedging, LLC
- Using Farm Credit Services of America "borrowing base" monthly

Dubuque, IA – June 12, 2019

Final Comments

- Don't loss milk or components
- Keep equipment current to control repair costs
- Take high speed out of skid loader

Dubuque, IA – June 12, 2019

Terry Van Maanen
712.470.2506
windingmeadows@gmail.com

Managing Costs on My Farm

Hunter Haven Farms
Pearl City, Illinois

Hunter Haven Farms was established in 1976, in Pearl City, IL, when Douglas & Edith Block and Thomas & Mary Block purchased the 320 acre "Home Farm" from Robert & Ruth Block (parents). The Registered Holsteins previously had the prefix of "Hunter Haven" as Robert had originally purchased the farm from Cape Hunter in 1948. After 1976 the Block families continued to build the herd of Registered Holsteins and increased hog production in the farrow to finish confinement facilities. Two smaller farms were eventually purchased -- "Bub's Farm" to the north where the large dairy is located, and the "Johnson Farm" which is located southeast of Pearl City. The Doug & Tom Block families continued to upgrade the 100 cow Registered Holstein herd, and market hog production increased to 1100 head per year. In the fall of 1996 the decision was made to expand the dairy herd and eliminate the hog production.

Hunter Haven Farms, Inc. was established March 1, 1997 and the construction of the new 400 cow dairy facility began. During the summer of 2000 a 100 stall addition was added to the existing 400 stall Dairy Free-stall Barn. In the spring of 2005 the Methane Digestor (partially grant funded) went on-line with electricity production and compost bedding production. During 2006 the construction of an additional 200 stall dairy free-stall barn was completed, allowing the dairy facility a capacity of approximately 900 cows. The mission of the farm is to foster an environment of personal growth and advancement for our families and employees; effectively manage resources for present and future generations, continuously improve their products in quality, value, and profitability. At present the farm is in the process to transfer the administration of the farm from the Block's to the employees Scott and Nathan.

Left: Scott Benner. Right: Doug Block

The Ins and Outs of Behavioral Well-Being for Dairy Cows

Jennifer Van Os
jvanos@wisc.edu
Animal Welfare Science at UW-Madison

The ins and outs of behavioral well-being for dairy cows

JENNIFER VAN OS

DEPARTMENT OF DAIRY SCIENCE University of Wisconsin-Madison

What is **animal welfare**?

state of individual animal: how ***well*** is she ***faring***?

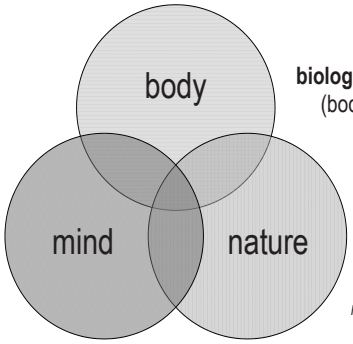
faring well: good welfare

faring poorly: poor welfare

animal welfare science looks at the state of the animal
→ it's **outcome** based

Animal welfare: critical for the **social license** to continue producing food in the future

What's important for animal welfare?



biological function
(bodily health)

Fraser et al. 1997. Anim. Welf. 6:187-205

affective (emotional) state
(**+** vs **–** experience)

species relevance
("behavioral well-being")

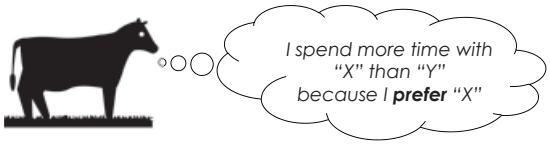
Research helps us understand what's needed for good welfare
– and how to accommodate those needs in a practical setting, and in light of stakeholder expectations

Biological science: understanding the cow

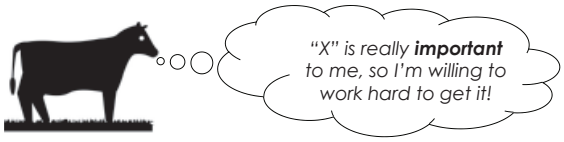
Social science: understanding people

What's a "behavioral need"?
How can we ask cows what matters to them?

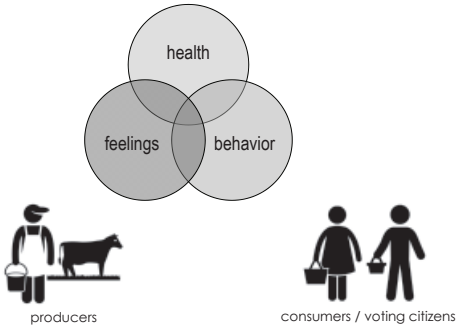
1. **Preference testing**: "voting" with their feet



2. **Motivation testing**: asking them to "pay" to show how much they care about something



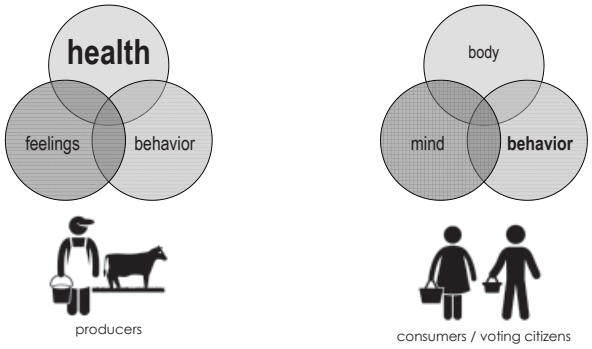
Social science research shows how different people prioritize aspects of animal welfare



Examples of what research can tell us about cattle welfare inside and outside of the barn:

1. What do **cows** think about being on pasture vs. in the barn?
2. How can we tell if cows are staying cool in summer?
3. How flexible are consumers on their expectation for pasture?

Both producers & consumers value all 3 aspects of welfare, but their **emphasis** sometimes differs

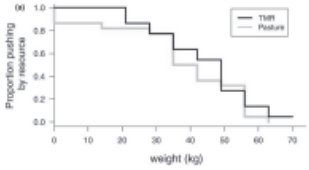


Cardoso et al. 2016; De Greef et al. 2005; Ventura et al. 2015, 2016

Cows are willing to work hard to gain access to pasture

Fresh TMR ✓

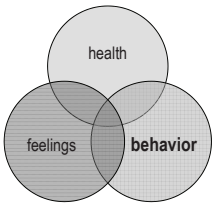
Access to pasture ✓



Pasture can have benefits for welfare:
- ✓ better air quality
- ✓ improved locomotion score
- ✓ fewer negative social interactions

von Keyserlingk et al. 2017. Sci. Reports 7:44953.

Consumers often have an expectation that animals live reasonably "natural" lives – especially having pasture access



***89%** of survey respondents uninvolved in dairy production think cows should have access to pasture*
Schuppli et al. 2014. J. Anim. Sci. 92:5185-5192.

consumers / voting citizens

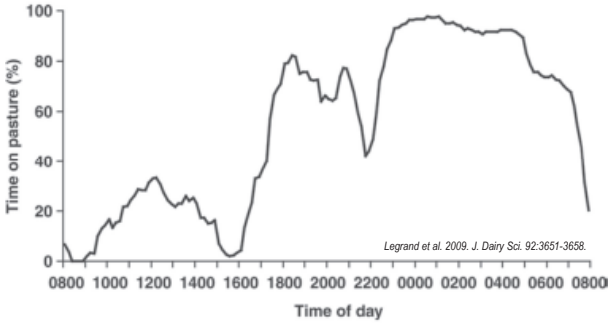
An ideal dairy farm is: "where the cows stay untied, on **pasture**, able to feed and walk **naturally**. Because I think that **freedom** should not be denied to any animal."

Cardoso et al. 2016. J. Dairy Sci. 102:1811-1821.

se also: Hötzel et al. 2017. J. Dairy Sci. 100:4150-4160

Cows prefer to be outside… AND inside

*Preference for pasture vs. the barn **depends** on time of day + weather*
*→ Choose pasture more at **night** (when it's not rainy)*



Legrand et al. 2009. J. Dairy Sci. 92:3651-3658.

See also: review by Charlton & Rutter, 2017; Falk et al. 2012; von Keyserlingk et al 2017; Smid et al. 2018

Cows chose to spend less time on pasture when it rained

Legrand et al. 2009. J. Dairy Sci. 92:3651-3658.

Mud can create costly problems

⇩ hygiene

⇧ digital dermatitis

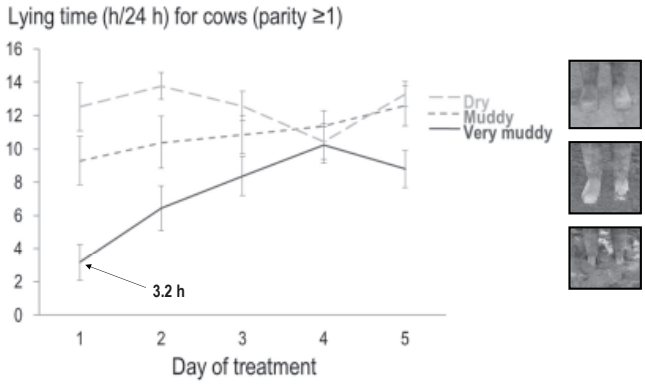
⇩ milk yield

*Müller et al 1996; Rodriguez-Lainz et al 1996; Fisher et al 2003; Stull et al 2008; Chen (**Van Os**) et al. 2017*

Examples of what research can tell us about cattle welfare inside and outside of the barn:

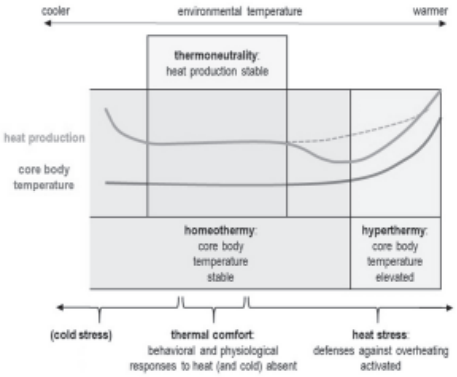
1. What do **cows** think about being on pasture vs. in the barn?
2. How can we tell if cows are staying cool in summer?
3. How flexible are consumers on their expectation for pasture?

Lying time was severely reduced in muddier conditions, especially in the first 24 hours



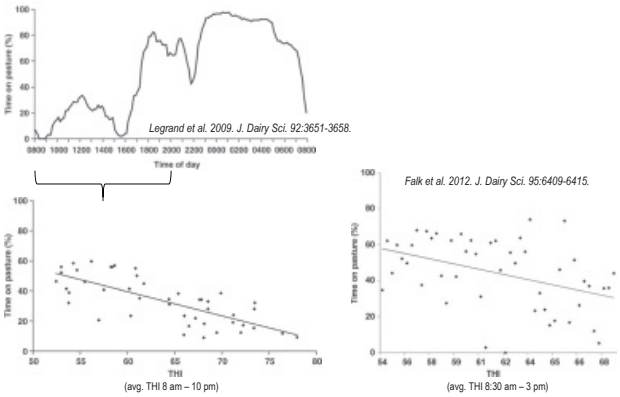
*Chen (**Van Os**) et al. 2017. J. Dairy Sci. 100:2090-2103.*

Rethinking the TNZ vs. thermal comfort



***Van Os**. 2019. Vet. Clin. N. Am. Food Anim. Practice 35:157-173*

Cows also choose to spend less time on pasture during the daytime… especially in warmer weather



Legrand et al. 2009. J. Dairy Sci. 92:3651-3658.

Falk et al. 2012. J. Dairy Sci. 95:6409-6415.

Early signs: changes in behavior and respiration rate

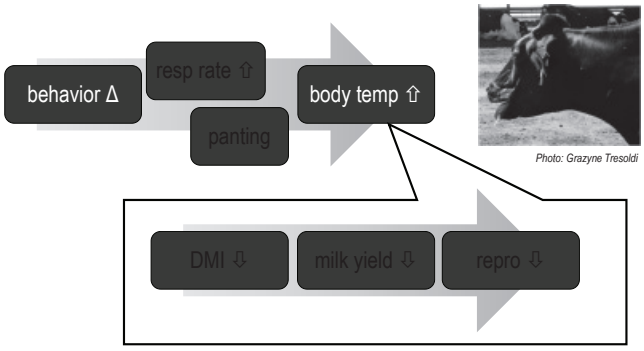
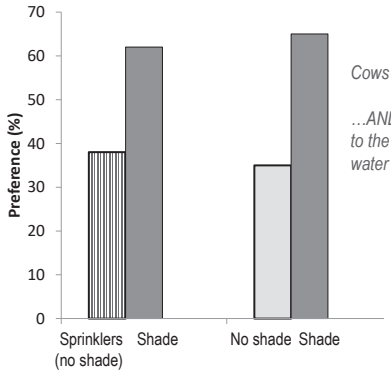


Photo: Grazyne Tresoldi

When cows are **outside** in warm weather, they want the benefits of shade



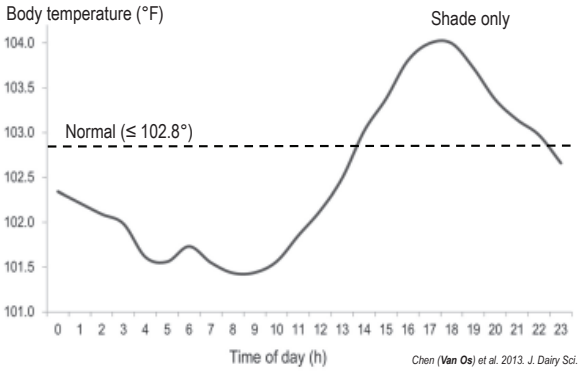
*Cows are **motivated** to seek shade…*

*…AND they **prefer** shade compared to the sun, even when cooled with water sprinklers*

Schütz et al., 2008, 2009, 2011; Tucker et al. 2008

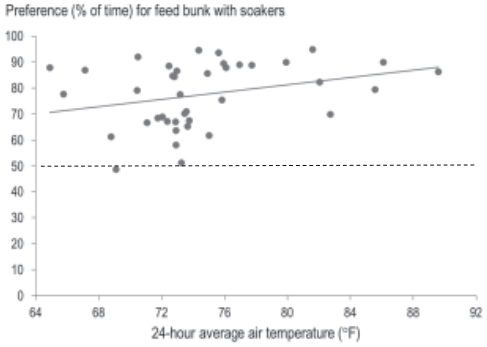
With only shade, body temp became elevated

(air temp = avg high of 97°F)



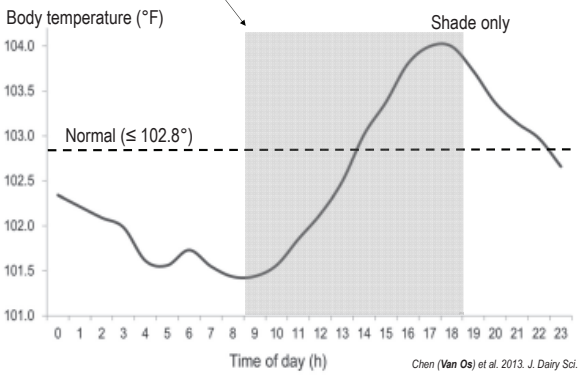
*Chen (**Van Os**) et al. 2013. J. Dairy Sci. 96:5035-5045.*

When soakers are mounted over feed bunks **with shade**, cows do prefer soakers, especially in warmer weather



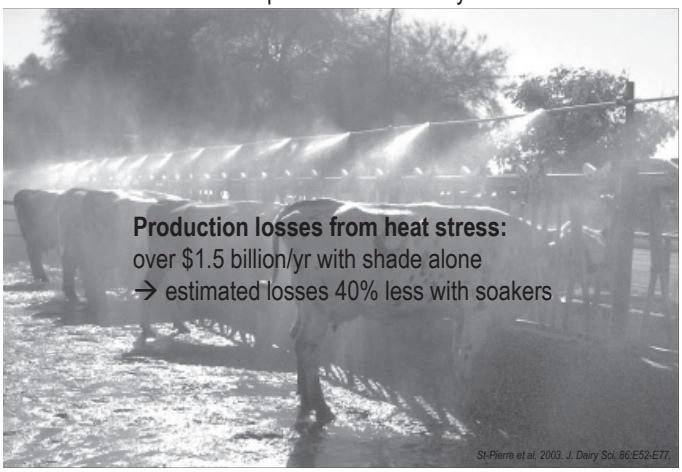
*Chen (**Van Os**) et al. 2013. J. Dairy Sci. 96:5035-5045.*

Cows chose to start using soakers in the morning (~THI 69)

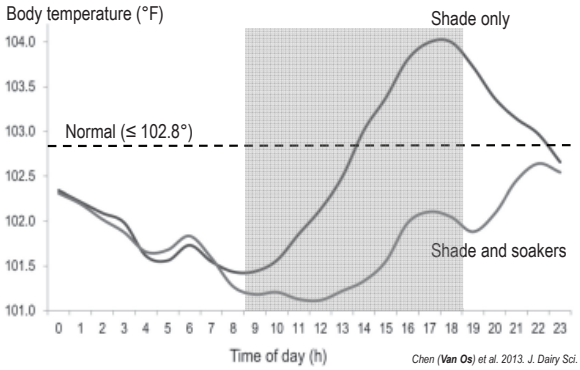


*Chen (**Van Os**) et al. 2013. J. Dairy Sci. 96:5035-5045.*

Soakers help cows release body heat



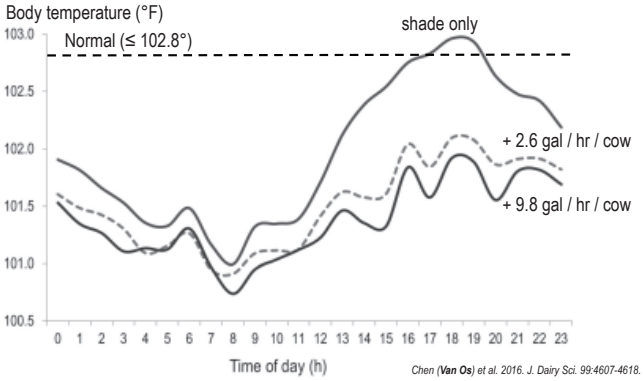
Body temperature stayed normal when cows had soakers



*Chen (**Van Os**) et al. 2013. J. Dairy Sci. 96:5035-5045.*

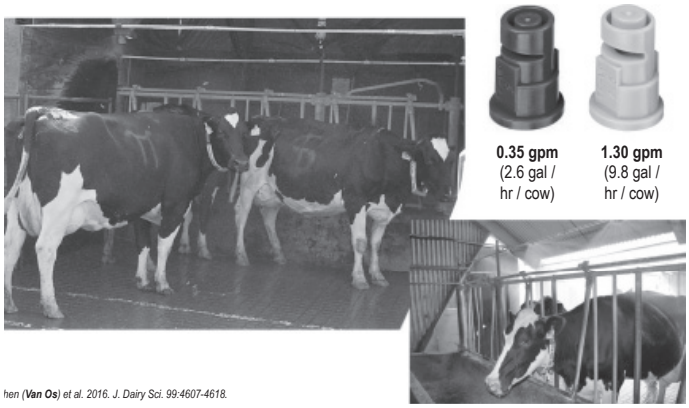
How much to spray? Common rule of thumb – is it right?

Body temperature stays lower when cows have soakers



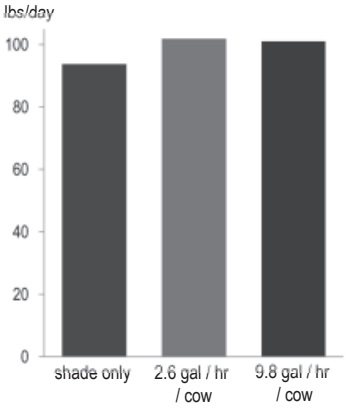
Chen (**Van Os**) et al. 2016. J. Dairy Sci. 99:4607-4618.

What's the right amount to spray?
→ compared soaker nozzles at the feed bunk



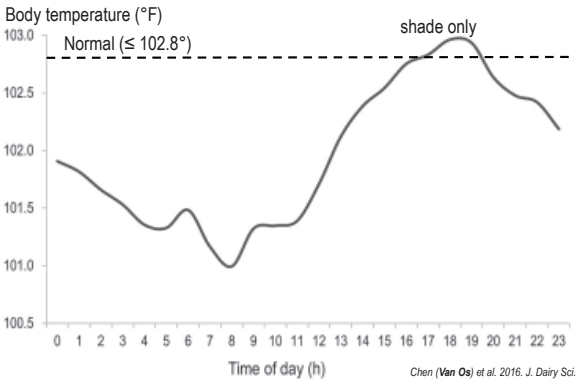
hen (**Van Os**) et al. 2016. J. Dairy Sci. 99:4607-4618.

Daily milk yield was >7 lb higher with soakers



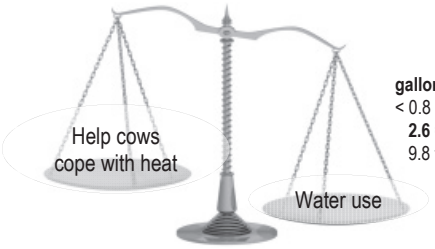
Chen (**Van Os**) et al. 2016. J. Dairy Sci. 99:4607-4618.

With no soakers, body temp went up
(air temp = avg high of 91°F)



Chen (**Van Os**) et al. 2016. J. Dairy Sci. 99:4607-4618.

Using water **efficiently** for cooling



gallons/hour per cow:
< 0.8 = not enough (*ineffective*)
2.6 = effective + efficient
9.8 too much (effective but *inefficient*)

…but measure how **your** cows respond

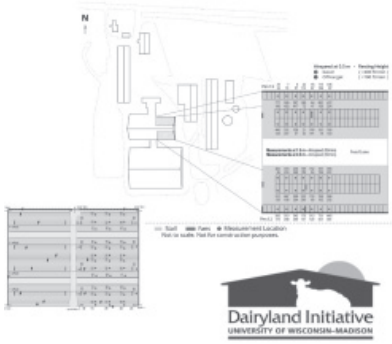
We evaluated the performance of cooling systems: mechanical ventilation with baffles, fans over stalls, showers

Successful farm owned by 4 UW-Madison alumni

2 barn types for lactating cows:
- Naturally ventilated (1997)
- Mechanically cross-ventilated (2007)

Showers in the milking parlor for more cow cooling

Measured consistency of airspeeds at cows' standing & resting heights



Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

*Mondaca, **Van Os**, Cook. ADSA 2019*

Predictions

Farm thinks mechanically cross-ventilated barn is more comfortable
→ strategically houses earlier-DIM / higher-producing cows there
(avg 109 vs. 77 lbs/day)

→ predict those cows will show fewer signs of heat stress, despite greater internal heat generation

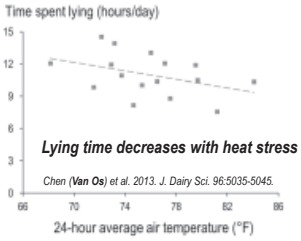
Elevated respiration rate: early indication of attempt to cope with heat stress

ThermalAid

Available on the App Store | Google play

Free app: thermalnet.missouri.edu/ThermalAid

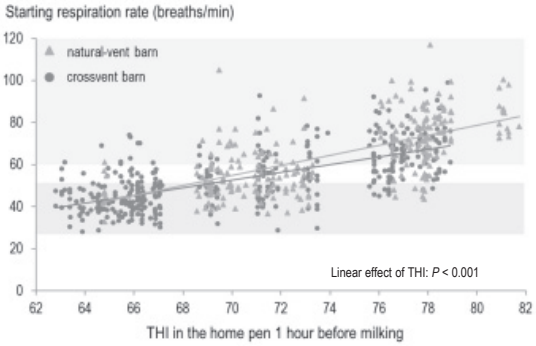
Measured consistency of airspeeds at cows' standing & resting heights



Dairyland Initiative
UNIVERSITY OF WISCONSIN–MADISON

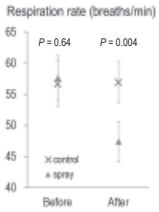
*See also: Chen (**Van Os**) et al. 2016; Legrand et al. 2011; Overton et al. 2002*

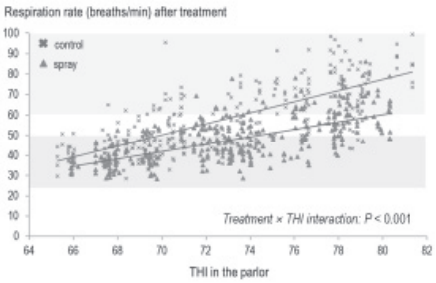
Before milking, cows' respiration rates were higher on warmer days



***Van Os** et al. ADSA 2019*

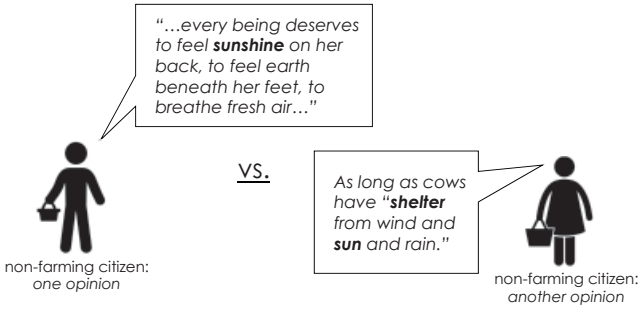
Brief showers during milking reduced respiration rate





***Van Os** et al. ADSA 2019*

Consumers' views on pasture vs. indoor housing can depend on shelter availability



Schuppli et al. 2014. J. Anim. Sci. 92:5185-5192.

Dairy producers and the industry have many good ideas for cow comfort

It's valuable to **measure** how well these solutions are performing – especially how the cows are responding

→ funded USDA CARE grant

***Van Os** and Cook, 2019-2022*

Consumers' views on pasture vs. indoor housing depend on the heat-stress abatement provided

Cardoso et al. 2018. PLoS ONE:13 e0205352.

Examples of what research can tell us about cattle welfare inside and outside of the barn:

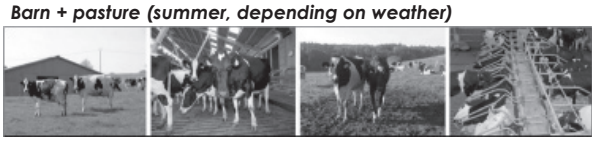
1. What do **cows** think about being on pasture vs. in the barn?
2. How can we tell if cows are staying cool in summer?
3. How flexible are consumers on their expectation for pasture?

What do consumers think of indoor+outdoor access?

Barn only

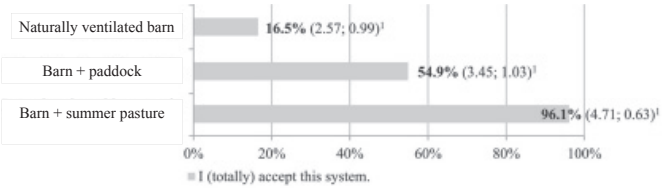
Barn + concrete paddock (year-round)

Barn + pasture (summer, depending on weather)



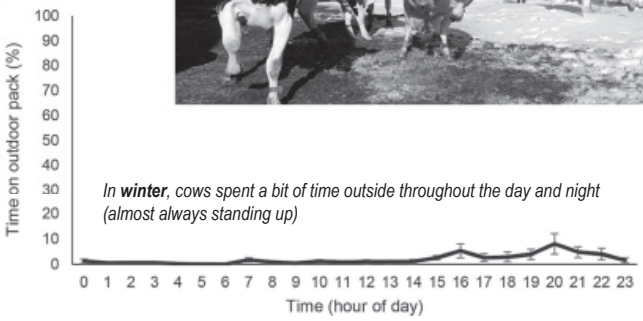
Kühl et al. 2019. Livest. Sci. 220:196-204.

Consumers were more supportive of barns with free-choice outdoor access, especially pasture



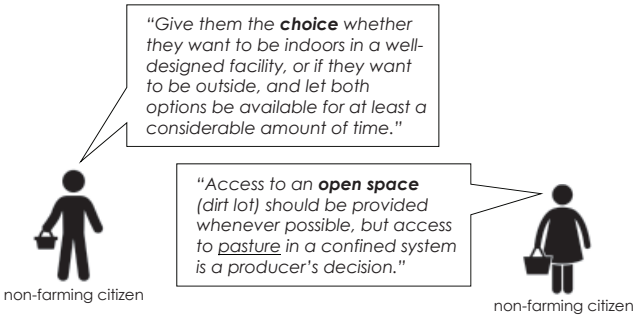
Kühl et al. 2019. Livest. Sci. 220:196-204.


Jennifer Van Os



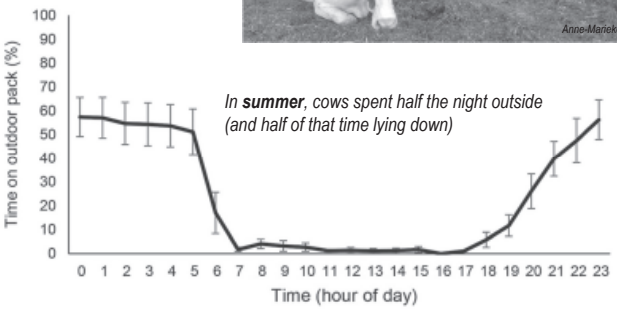
Smid et al. 2019. J. Dairy Sci. 102:1551-1558.

What do consumers think of indoor+outdoor access?



Schuppli et al. 2014. J. Anim. Sci. 92:5185-5192.


Anne-Marieke Smid



Smid et al. 2019. J. Dairy Sci. 102:1551-1558.

What do **cows** think about non-pasture outdoor areas?


Anne-Marieke Smid

Take-home messages

- ✓ Animal welfare is important for the cow, the producer, and the consumer
- ✓ Soakers + high-speed air can help keep cows cool. It's valuable to **measure** how well cows are coping
- ✓ When given the choice, cows go outside during **summer nights**, but they prefer the barn for shelter from the elements (heat/sun, rain)
- ✓ Outdoor exercise areas may be an alternative to pasture

Jennifer Van Os
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Animal Welfare Science at UW-Madison

Economic Aspects of Cow Longevity

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University of Florida - Gainesville
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Economic Aspects of Cow Longevity

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University of Florida
Gainesville, FL 32611
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UF IFAS UNIVERSITY of FLORIDA

Four State Dairy Nutrition and Management Conference, Dubuque, IA. June 12-13, 2019

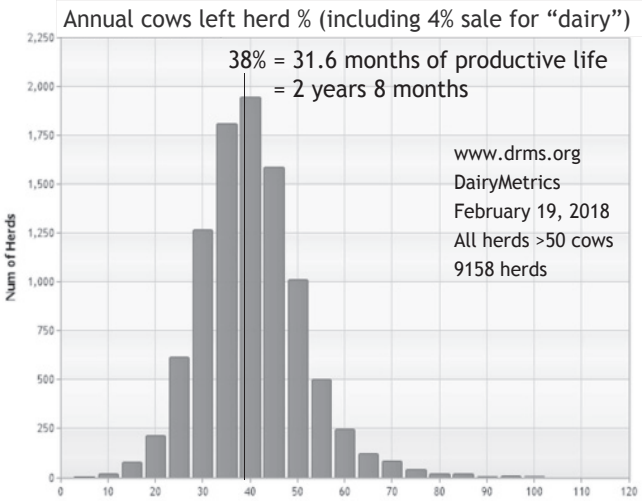
Cow longevity

"The oldest known cow was Big Bertha who was almost 49 when she passed away on New Years Eve in 1993. Big Bertha produced 39 calves"

Natural lifespan is about 20 years

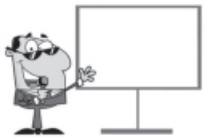
Farmer Jerome O'Leary in the Blackwater Tavern with Big Bertha.

The goal of this presentation is to draw attention to culling risks and economics of culling. Can and should the dairy industry do better?



Overview

- Longevity statistics
- Risk factors for culling
- Economics of longevity
- Culling decision support
- Summary

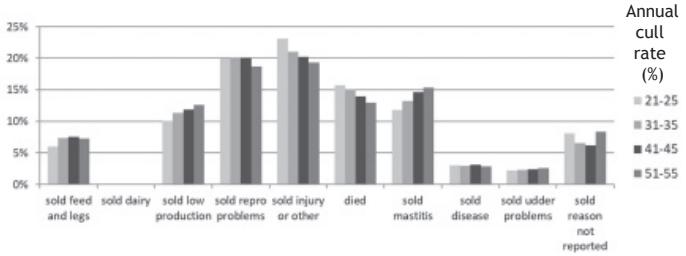


Culling mathematics

1. If national herd size is constant
2. If 1.1 calves born per cow per year
3. If all female calves are raised to become milking cows (no sexed semen)
4. Then national annual cull rate ≈35%
   - Productive life = 1/35%*12 = 34.3 months
   - Cows are culled to make room for calving heifers

Risk factors for culling

Culling reasons are similar in herds with different cull rates



Source: 11,985 DHIA herds

Statistics for 8,400 U.S. dairy herds on DHI milk test, sorted by % cows left per year

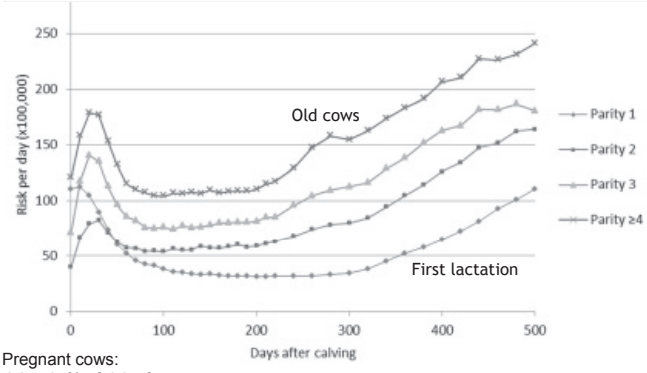
ows left per year (%)	18	25	31	38	45	52	**59**
lerds (N)	208	797	1823	**2289**	1566	789	314
ows (N)	87	172	213	**258**	213	184	141
ows left alive per year (%)	14	20	26	33	39	45	**52**
ows died per year (%)	3.9	4.3	5.0	5.3	5.9	6.2	**6.3**
omatic cell count (x1000)	**252**	228	224	209	202	218	225
olling milk yield (kg/yr)	8,144	9,526	10,136	10,535	**10,610**	10,598	10,250
alving interval (mo)	**14.3**	13.8	13.6	13.4	13.4	13.4	13.5
reg Rate-Year Ave	17.3	18.2	19.2	**20.2**	19.7	18.5	18.4
let Merit $ for All Cows	37	104	125	145	146	**151**	122
ge of 1st Lact Cows (mo)	**27.0**	26.2	25.5	25.1	25.1	25.2	25.4
ongevity (years), incl. sale	**7.96**	6.23	5.32	4.73	4.33	4.04	3.83
ongevity (years), sale adj.	**9.66**	7.01	5.79	5.04	4.55	4.21	3.95

Source: DRMS (2019). Available at www.drms.org Accessed March 10, 2019

Large Florida dairy producer on longevity:

- *"25 years ago I thought what was a good long lived cow was all type related."*
- *"One day I made a list of all our oldest cows to try to find out what their commonality was. Nobody was going to win a show. No records were being set. They all got bred the first or second time (mostly first) and never went to the hospital. They were all the cows you only saw twice a year."*
- *"I wonder if some longevity benefit is just from cows not shoved into too small of a hole. Management has a lot of effect."*

Risk of culling (including death) per day (non-pregnant cows). Holstein herds in the USA



Pregnant cows:
risk = 25% of risk of open cows

De Vries et al. (2010) J. Dairy Sci. 93:613

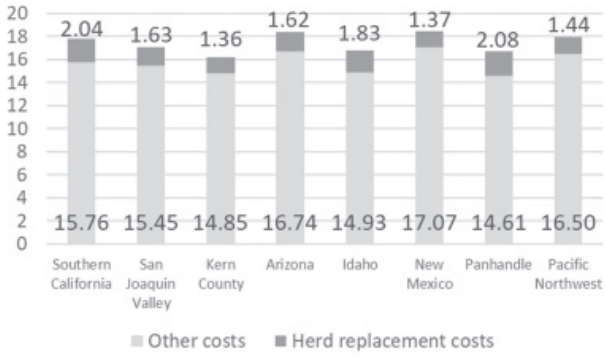
Economics of longevity

Lifetime profit is not the goal

- Rule: optimize profit per unit of most liming factor
  - $/cow/year
  - $/milking cow/year
  - $/lbs phosphor/year
  - $/acre/year
  - $/labor unit/year
  - ….

Herd replacement costs per cwt milk

≈ 10% of total operational cost



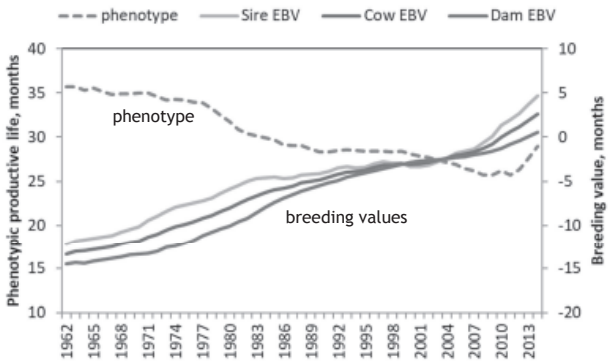
Frazer LLC, Dairy Farm Operating Trends, December 31, 2017

Depreciation costs

- Heifer rearing/purchase costs: $1500 to $2500
  - 2019: 8-month pregnant heifers sold for: <$1000
- Salvage value: $500 to $1000 (5% dead)
- Depreciation = heifer cost – salvage value

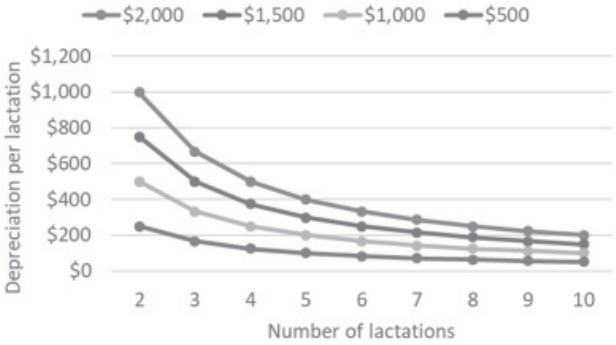
annual replacement percentage	productive life (years)	depreciation per cow $ 1,500	$ 1,000	$ 500
15%	6.67	$ 225	$ 150	$ 75
20%	5.00	$ 300	$ 200	$ 100
25%	4.00	$ 375	$ 250	$ 125
30%	3.33	$ 450	$ 300	$ 150
35%	2.86	$ 525	$ 350	$ 175
40%	2.50	$ 600	$ 400	$ 200
45%	2.22	$ 675	$ 450	$ 225

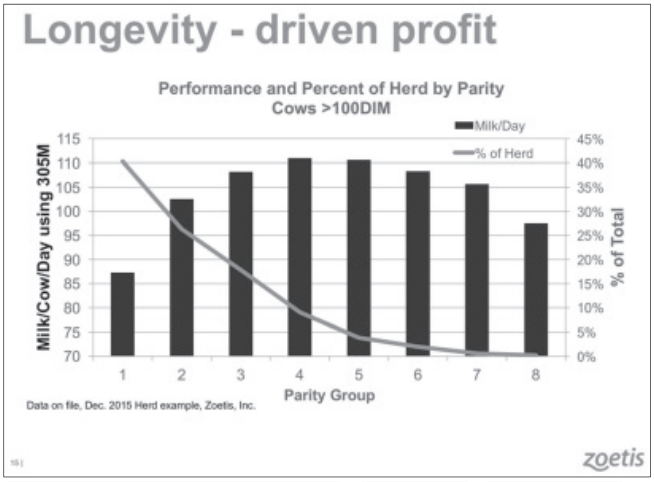
Productive life (longevity) for Holsteins in USA phenotype and breeding values



Source: https://www.cdcb.us/eval/summary/trend.cfm

Cow depreciation per lactation



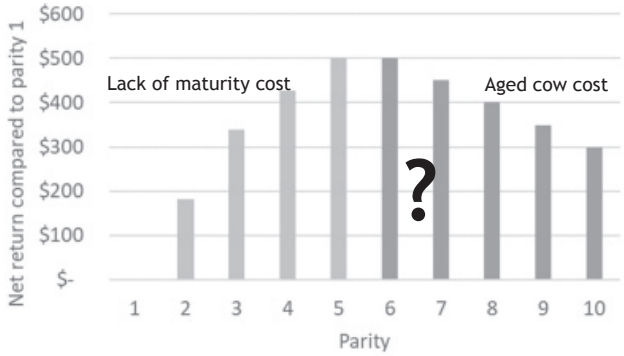


More lactations: replacement cost ↓, milk yield ↑, genetic level ↓

Genetic improvement

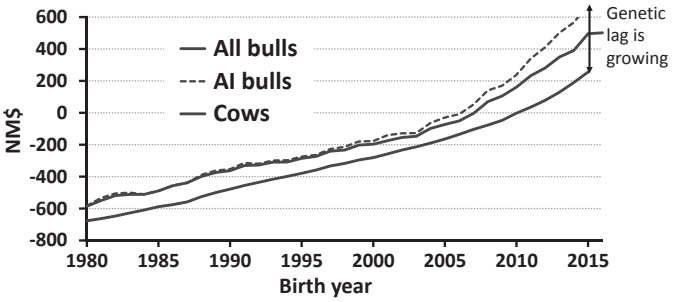
1950 champion cow: 154 000 lb milk in 13 lactations
11,846 lb/lactation

Difference in net return per parity



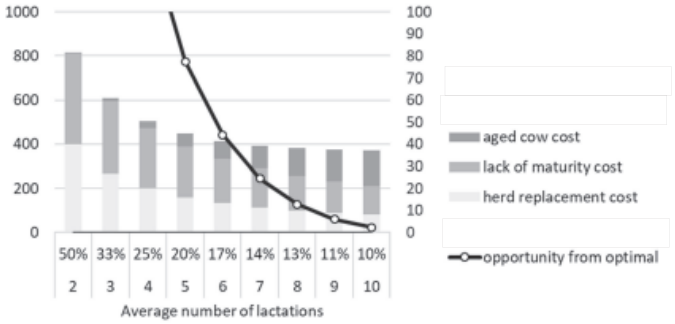
Without genetic progress

Genetic trend (PTA Net Merit$ selection index)



Lifetime Net Merit = economic selection index from USDA

Cost of herd structure



$/year

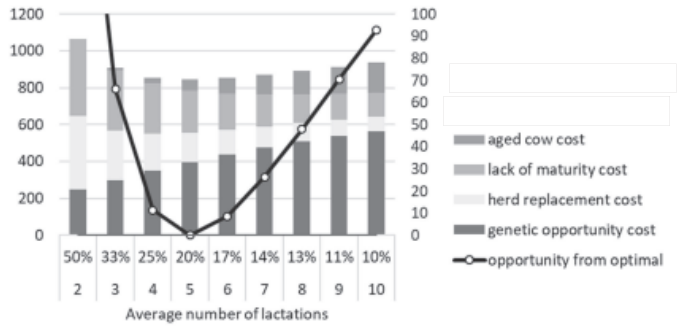
Literature Review: Culling <=> Genetics

After review of existing work: Increased genetic progress in sires should increase cow cull rates by *a few percent* at most.

De Vries (2017), J. Dairy Sci. 100:4184-4192

Cost of herd structure

Genetic opportunity cost

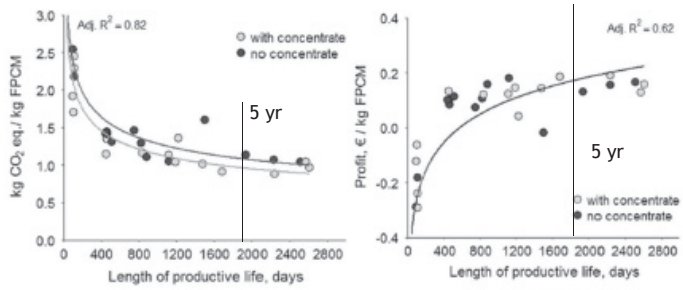


$/year

Productive life: green house gasses, profitability

Green house gas

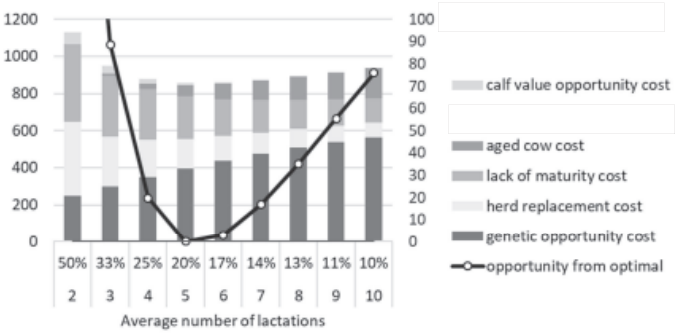
Profit/kg milk



Grandl et al. (2019). Animal 13:1 p198

Cost of herd structure

Premium for crossbred calves



$/year

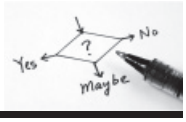
Culling decisions support

Observations on cost of herd structure

- Optimum often >4 years (25% cull rate)
- Optimum sensitive to inputs
- Extended longevity most valuable:
  - Heifer cost >> salvage value
  - High milk price, low feed cost
  - High premium crossbred calves
  - Little genetic progress
  - Good aged cows

Is there something to decide?

- Most culling is for economic reasons (Fetrow et al., 2006)
- Criteria for culling vary between farmers (Beaudeau et al., 1996)
- Differences between farmers and advisors (Haine et al., 2017)
- Culling decisions are not a priority (Huire et al., 1993)
- But: Frequent calls for decision support
- Older decision models: ≤30% annual replacement is economically optimal (Fetrow et al., 2006)
- But: optimal replacement rate is farm dependent



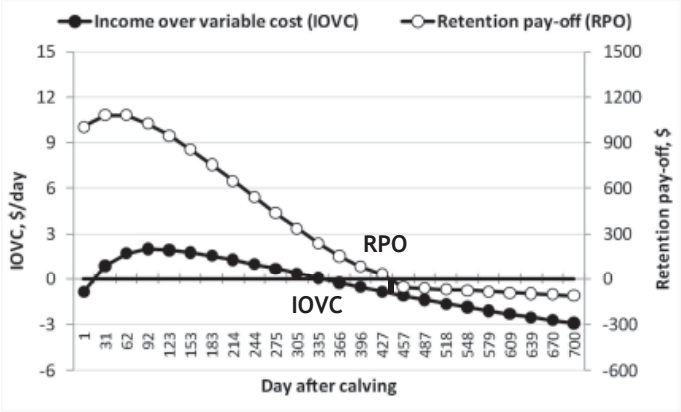
Optimal replacement decisions

Complicated: need to predict future cash flows of incumbent and challenging cow(s)

- Consider **opportunity cost** = cost sacrificed on an average challenging cow by keeping the incumbent cow in the herd *(Van Arendonk, 1991)*

Future cash flow (incumbent)
- Future cash flow (challenger)
= Retention pay-off (RPO)

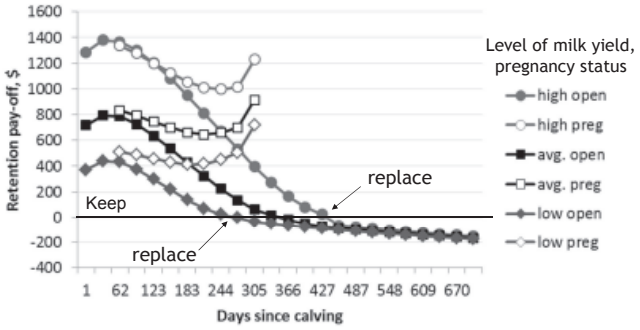
2 criteria for culling: Lower milk price



Parity 1, milk price $0.13/lbs

Value of keeping the cow in the herd

Compared to immediate replacement with a heifer



Higher milk yield and pregnancy protect against culling

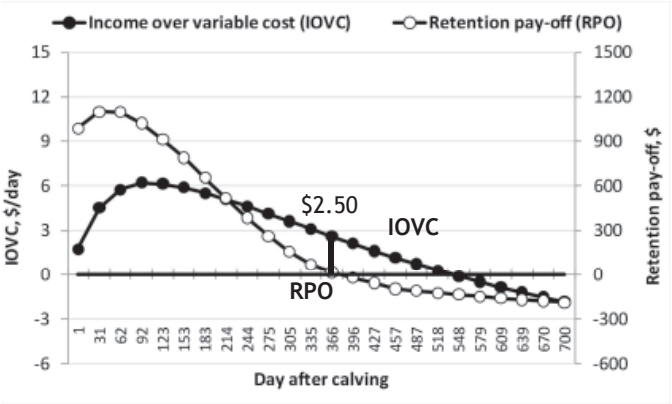
Keep Value and Keep Pct

in Florida herd with 1300 cows

012 - COMBINATION-- LOW COWS & 30 DAY DRY-OFF barn#2

G R P	Index	Days In Milk	Prev T.D. Milk	Curr T.D. Milk	KEEP VALUE	KEE PCT	Pre SCC Act	Cur SCC Act	LTD Milk	Proj ME Milk	R A T	No Br	C D E	Bred Heat Date	Due Date	Date To Dry
7	1437	434	50.0	48.5	-413	3	1131		24799	22473	D		C			
16	72	64		11.6	-382	4										
7	490	398	53.0	52.4	-361	4	325		22484	21350	C		C			
6	2194	350	58.0	44.6	-310	4	141		21872	26304	B		C			
16	77	63		15.5	-229	5										
7	1330	210	44.0	44.6	-243	5	1600		5621	13553	E		C			
7	409	366	48.0	44.6	-133	6	93		24323	24235	B		C			
16	73	64		31.0	-26	7										
16	61	69		36.9	231	11										
7	1859	289	44.0	34.9	298	14	33		15139	19246	E	1	P	08/07	05/13	03/19
7	2791	242	55.0	36.9	306	14	33		9021	20905	D	2	P	10/08	07/14	05/20
4	2866	202	69.0	68.0	344	15	3430		8401	26884	A		C			
7	1198	310	41.0	34.9	413	17	100		15790	18697	E	1	P	07/17	04/22	02/27
7	2291	279	56.0	34.9	412	17	54		12804	20768	D	1	P	08/14	05/20	03/26
8	1754	281	66.0	46.6	513	22	123		15621	23069	D	1	P	08/14	05/20	03/26
7	2513	394	42.0	29.1	523	23			17904	21607	C	4	P	08/18	05/24	03/30
7	2642	315	45.0	36.9	561	24	141		11638	18001	E	1	P	07/10	04/15	02/20

2 criteria for culling: Average milk price



Parity 1, milk price $0.19/lbs

Going through the cull list

B = beef = cull

Summary

- Average longevity has changed little over time
- All culling driven by economics (choice)
- Increasing longevity makes economic sense
- Faster genetic progress reduces optimal longevity, a little
- Do we nee better tools to support replacement decisions?

Thank you

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The Impact of Transition Cow Disease: Why Its Greater Than We Realize

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The Impact of Transition Cow Disease: Why It's Greater Than We Realize

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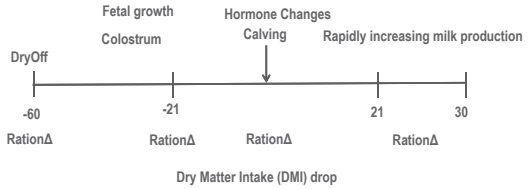
THE VITAL 90 DAYS

Transition Cow



A 90 day collection of transition periods that have interrelated events influencing either productive or non-productive outcomes in the lactation

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To Quantify the Financial Impact of Milk NOT Produced Due to Disease…What Information is Needed?

- How much disease is present?
- What is the typical or expected impact of disease on milk production?
- What is the value of the milk that is not produced?
- Value and quantity of feed that is not consumed due to milk not being produced

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- When estimating the feed cost associated with incremental milk, we do not have to consider maintenance feed; we only have to account for the energy required to produce the marginal milk
- To produce 1 liter of milk with 3.8% fat, 3.1% protein, and 4.8% lactose:
  - Each gram of fat requires 9.3 kcal gross energy: 38 g milk fat * 9.3 = 353 kcal
  - Each gram of protein requires 5.5 kcal gross energy: 31 g protein * 5.5 = 171 kcal
  - Each gram of lactose requires 4.0 kcal gross energy: 48 g lactose * 4.0 = 192 kcal

    Total 716 kcal
- 716 kcal/ liter = 0.72 Mcal NE_L/ liter or 0.33 Mcal NE_L/ lb of marginal milk
- If TMR energy density = 0.78 Mcal NE_L/ lb

  ➔ 1 lb TMR DM supports 0.78/0.33 = 2.36 lb milk
- If feed cost = $0.11/lb, 1 lb marginal milk requires 0.11/2.36 = $0.05 feed
- $0.05 of feed to produce an *extra* or incremental lb of milk

(NRC. 2001. 7th ed. National Academy Press, Washington, p. 19.)

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What Can We Do in Early Lactation to Combat Transition Challenges?

- Use high quality feed ingredients (properly balanced with sufficient fiber) to promote feed intake
- Manage environment to minimize stress and weight loss during fresh period
- Provide adequate and comfortable resting access
- Remove other stressors (overcrowding, mixed parities, excessive standing times, excessive walking distances, etc)
- Consider specific feed additives, pharmacologic interventions
- Be careful with pen moves
- Promptly identify and appropriately treat fresh cow disorders

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Management in The Vital 90™ Days is Critical:

*RISK, **COSTS**, and OPPORTUNITY*

Two Major Types of Costs During The Vital 90 Days

Investment Costs (Expenditures)

- Dairy producers often invest heavily to mitigate the *RISK* associated with calving
- Many products and procedures are justifiably used to reduce disease and optimize performance

Consequence Costs (Losses)

- Direct and indirect costs of disease are a major source of economic loss and frustration for dairy producers
- Lowering consequence costs through reducing disease and refining treatment decisions is a great opportunity to improve profitability

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When Estimating the Cost of Disease, There are a Number of Issues that Need to be Considered

- **Direct disease costs (losses)**:
  - Diagnostics – is there any kind of special screening or lab test that is performed?
  - Therapeutics – what are the various antimicrobials, supportives, anti-inflammatories, etc that are used in treatment?
  - Discarded milk – how much milk is being discarded and for how long? What is the true value of this milk? Is it used to feed calves or discarded?
  - Veterinary service – is the vet involved with either diagnosis or treatment of this issue?
  - Labor – how much of my on-farm labor's time is used to diagnose or treat this issue?
  - Death – how many cows die as a consequence of this disease and what is the true economic impact to the dairy?

Estimating Cost of Disease: Issues that Need to be Considered

- **Indirect disease costs (lost opportunity)**:
  - Milk production loss – how much marginal milk is NOT produced throughout lactation as a result of this disease issue and what is that worth?
  - Culling loss – how many cows leave the herd prematurely as a consequence of this issue and what is the economic impact to the dairy?
  - Reproductive loss – how much is my reproductive performance negatively impacted by this issue and what could that be costing the herd?
  - Losses due to other attributable disease issues – are there any other disease issues that are impacted by the occurrence of this issue?

To Quantify the Financial Impact of Milk NOT Produced Due to Disease…What Information is Needed?

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(NRC. 2001. 7th ed. National Academy Press, Washington, p. 19.)

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How Do We Monitor Transition Cows?

- NEFAs or BHBAs
- Urine pH
- Stocking density
- Ca +/- Mg at calving
- Daily milk (start up milk)
- Early lactation milk (first test milk)
- Peak milk
- p305ME milk
- SCC
- 1st test fat or fat:protein
- Feed intake
- Disease incidence
- % Sold and Died
- Rectal temperature
- Ruminations
- Resting time

Cow vs. herd level metrics; Leading vs. lagging metrics;
Some metrics are better than others for making timely decisions

Recorded Disease Incidence in US Holstein Cows in the DDAS System (Herd-level)

	Mastitis (1st 30 DIM)		Metritis		Retained Placenta		LDA (1st 30 DIM)	
	Lact = 1	Lact > 1	Lact = 1	Lact > 1	Lact = 1	Lact > 1	Lact = 1	Lact > 1
"X" Herds	6.8%	6.6%	22.7%	13.6%	3.7%	7.5%	1.3%	3.3%
"Y" Herds	5.0%	6.5%	9.5%	4.6%	2.6%	4.0%	1.8%	2.1%

Variables included in model included Herd, Month of Calving, Year of Calving, Calf (male, female, twin) and Lactation Group

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Milk Production for Holstein Cows in the DDAS System

	Cumulative Milk 30		Projected 305 Milk	
	Lactation = 1	Lactation > 1	Lactation = 1	Lactation > 1
"X" Herds	1,698 lb	2,526 lb	22,779 lb	26,372 lb
"Y" Herds	1,585 lb	2,244 lb	20,192 lb	23,331 lb
Difference	113 lb	282 lb	2,587 lb	3,041 lb

Variables included in model included Herd, Month of Calving, Year of Calving, Calf (male, female, twin) and Lactation Group

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Culling in First 60 DIM

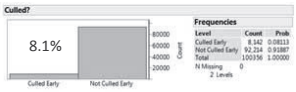
Lactation = 1

"X" Herds

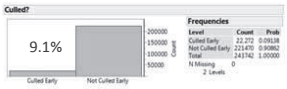
"Y" Herds

Lactation > 1

"X" Herds



"Y" Herds



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Recorded Disease Incidence in Holstein Cows in the DDAS System (Herd-level)

	Mastitis (1st 30 DIM)		Metritis		Retained Placenta		LDA (1st 30 DIM)	
	Lact = 1	Lact > 1	Lact = 1	Lact > 1	Lact = 1	Lact > 1	Lact = 1	Lact > 1
"X" Herds	6.8%	6.6%	22.7%	13.6%	3.7%	7.5%	1.3%	3.3%
"Y" Herds	5.0%	6.5%	9.5%	4.6%	2.6%	4.0%	1.8%	2.1%

Variables included in model included Herd, Month of Calving, Year of Calving, Calf (male, female, twin) and Lactation Group

All of these herds were Holstein herds
"X" herds appeared to more consistently record mastitis and metritis
"Y" herds failed to consistently record mastitis, metritis, or both on a consistent basis

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Accurately Recording Disease Occurrence, Even if it is NOT Treated, is Critical for Understanding the Impact of Disease on a Herd and for Improving Management

- In the previous examples:
  - The "X" herds produced more milk and had lower culling risk despite having MORE *recorded* disease
  - Disease incidence is much more susceptible to detection and recording bias as compared to more subjective outcomes such as milk production and culling (sold & died)
- Most herds only record what they treat as opposed to what actually occurs
  - To better understand the impact of disease on a herd, we need to identify all disease whether treated or left untreated

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How Much Does the Failure to Record Disease Affect the *Measurable* Impact of Disease?

- Introduces bias into the system
- Types of bias/recording issues:
  - Failure to record any disease
  - Failure to correctly distinguish mild from severe
  - Failure to record mild disease
  - Misclassification of a normal cow as "diseased"

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Metritis Severity Score *Misclassification* Under Predicts Consequence Cost Of Disease*

- Convenience sample of DC305 data from 1 Mid-Western Holstein herd
  - 1 year of calvings (n = 3,485)
- Herd chosen because it does an excellent job of recording metritis incidence & severity
  - No metritis recorded (**NR**)
  - Mild metritis
  - Severe metritis

*McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

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Metritis score classification (misclassification)

	Metritis severity as recorded	
	Normal herd recorded data 1. No metritis recorded 2. Mild metritis 3. Severe metritis	
Cow Numbers (by Metritis severity)	**Number**	**% of herd**
None	2,353	71.8%
Mild	810	24.7%
Severe	114	3.5%
Total	3,277	100.0%
Total metritis	924	28.2%
Mild "under-recorded"		

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

Elanco Animal Health. Data on File.

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Metritis score classification (misclassification)

	Metritis severity as recorded		Mild cases under-recorded	
	Normal herd recorded data 1. No metritis recorded 2. Mild metritis 3. Severe metritis		Randomized 45% of mild cases to "not recorded" 1. No metritis recorded 2. Mild metritis 3. Severe metritis	
Cow Numbers (by Metritis severity)	**Number**	**% of herd**	**Number**	**% of herd**
None	2,353	71.8%	2,716	82.9%
Mild	810	24.7%	447	13.6%
Severe	114	3.5%	114	3.5%
Total	3,277	100.0%	3,277	100.0%
Total metritis	924	28.2%	561	17.1%
Mild "under-recorded"			363	44.8%

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

Elanco Animal Health. Data on File.

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Metritis score classification (misclassification)

	Metritis severity as recorded		Mild cases under-recorded		Mild cases not recorded	
	Normal herd recorded data 1. No metritis recorded 2. Mild metritis 3. Severe metritis		Randomized 45% of mild cases to "not recorded" 1. No metritis recorded 2. Mild metritis 3. Severe metritis		All mild metritis cases reclassified as "not recorded" 1. No metritis recorded 2. Severe metritis	
Cow Numbers (by Metritis severity)	**Number**	**% of herd**	**Number**	**% of herd**	**Number**	**% of herd**
None	2,353	71.8%	2,716	82.9%	3,163	96.5%
Mild	810	24.7%	447	13.6%	0	0.0%
Severe	114	3.5%	114	3.5%	114	3.5%
Total	3,277	100.0%	3,277	100.0%	3,277	100.0%
Total metritis	924	28.2%	561	17.1%	114	3.5%
Mild "under-recorded"			363	44.8%	810	100.0%

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

Elanco Animal Health. Data on File.

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Statistical Approach for Analyzing Milk Production

- 2nd Test 305 ME milk was analyzed via multi-variable regression models for each of the metritis score classifications
- Explanatory variables included in the models
  - Lactation group
  - Month fresh
  - Twin or singleton
  - Dystocia Y/N
  - Early disease in first 30 DIM Y/N
    [Mastitis, RP, Ketosis, DA, Metritis (severe, mild)]

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

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Predicted 305M and Associated Losses

	Metritis Severity as Recorded (Actual)	
Cow Numbers (by Metritis severity)	**Number**	**% of Herd**
None	2,353	71.8%
Mild	810	24.7%
Severe	114	3.5%
Total	3,277	100.0%
Total metritis	924	28.2%
Mild "under-recorded"		
Milk Production (by Metritis Severity)	**305ME (lb)**	**Diff vs. None**
Herd Average	26,930	573
None	27,204	0
Mild	26,357	-847
Severe	25,338	-1866
Milk Loss Due to Metritis		
Actual Milk Loss		-898,826
Apparent Milk Loss		
Cost of *Apparent* Milk Loss		-$110,427
Difference from Actual (Value)		base
Difference from Actual (lb)		base

Based on milk price of $0.17/lb, feed cost of $0.11/lb, and 0.43 lb of feed (DM) per lb of milk

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

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Predicted 305M and Associated Losses

	Metritis Severity as Recorded (Actual)		Mild Cases Under-recorded	
Cow Numbers (by Metritis severity)	**Number**	**% of Herd**	**Number**	**% of Herd**
None	2,353	71.8%	2,716	82.9%
Mild	810	24.7%	447	13.6%
Severe	114	3.5%	114	3.5%
Total	3,277	100.0%	3,277	100.0%
Total metritis	924	28.2%	561	17.1%
Mild "under-recorded"			363	44.8%
Milk Production (by Metritis Severity)	**305ME (lb)**	**Diff vs. None**	**305ME (lb)**	**Diff vs. None**
Herd Average	26,930	573	26930	541
None	27,204	0	27083	0
Mild	26,357	-847	26389	-695
Severe	25,338	-1866	25412	-1671
Milk Loss Due to Metritis				
Actual Milk Loss		-898,826		-898,826
Apparent Milk Loss				-501,134
Cost of *Apparent* Milk Loss		-$110,427		-$61,568
Difference from Actual (Value)		base		$48,859
Difference from Actual (lb)		base		397,692

Based on milk price of $0.17/lb, feed cost of $0.11/lb, and 0.43 lb of feed (DM) per lb of milk

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

USDBUPOS00280

Predicted 305M and Associated Losses

	Metritis Severity as Recorded (Actual)		Mild Cases Under-recorded		Mild Cases NOT Recorded	
Cow Numbers (by Metritis severity)	Number	% of Herd	Number	% of Herd	Number	% of Herd
None	2,353	71.8%	2,716	82.9%	3,163	96.5%
Mild	810	24.7%	447	13.6%	0	0.0%
Severe	114	3.5%	114	3.5%	114	3.5%
Total	3,277	100.0%	3,277	100.0%	3,277	100.0%
Total metritis	924	28.2%	561	17.1%	114	3.5%
Mild "under-recorded"			363	44.8%	810	100.0%
Milk Production (by Metritis Severity)	**305ME (lb)**	**Diff vs. None**	**305ME (lb)**	**Diff vs. None**	**305ME (lb)**	**Diff vs. None**
Herd Average	**26,930**	**573**	**26930**	**541**	**26930**	**26930**
None	**27,204**	**0**	**27083**	**0**	**26985**	**0**
Mild	**26,357**	**-847**	**26389**	**-695**	**0**	**-26985**
Severe	**25,338**	**-1866**	**25412**	**-1671**	**25485**	**-1499**
Milk Loss Due to Metritis						
Actual Milk Loss		**-898,826**		**-898,826**		**-898,826**
***Apparent* Milk Loss**				**-501,134**		**-170,941**
Cost of *Apparent* Milk Loss		**-$110,427**		**-$61,568**		**-$21,001**
Difference from Actual (Value)		**base**		**$48,859**		**$89,426**
Difference from Actual (lb)		**base**		**397,692**		**727,885**

Based on milk price of $0.17/lb, feed cost of $0.11/lb, and 0.43 lb of feed (DM) per lb of milk

McCarthy, M. M. and M. W. Overton (2018). Journal of Dairy Science 101(6): 5434-5438.

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Implications

- Misclassification of metritis results in greater bias and underestimates the true association between metritis and milk production, reproductive performance and culling risk
  - Misclassification leads to an underestimate of the consequence costs of diseases like metritis
- Improved definition and recording of metritis herds can lead to better interpretation of the true impact of metritis (and other diseases) on individual herds

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The Subsequent Data are from the Previously Mentioned "X" Herds

- All herds use either DC305 or PCDART
- Selected an 18-month period of calvings (1/1/15 - 6/30/16)
  - Eliminated herds that had unreasonably low recorded incidences of mastitis, metritis, RP and DA
  - Eliminated herds that did not have milk production information
  - Filtered to include only Holstein cows
- Result: 158,676 lactation records from 28 herds in 12 states:
  - CA, CO, FL, GA, ID, IN, KS, MI, MN, NC, NY, and WI
- REMEMBER: This is observational analyses of farm reported information

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Disease Incidence – Cow-level (within 30 DIM)

All Cows:

Lactation = 1:

Lactation > 1:

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High-Level Overview of the Analyses Performed

- Separate models for lactation = 1 and lactation > 1
- Multivariable models to examine:
  - Projected 305d Milk
  - Time-to-removal by 60 DIM (sold or died)
  - Time-to-pregnancy by 250 DIM
- Estimated the value of milk not produced using concept of marginal milk value
- Estimated losses associated with culling using depreciated cow model
- Estimated losses associated with reproductive losses using median days open

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Summarization of Estimated Disease Impacts in this U.S. Data Set (using projected 305 Milk)

	Variable	305 Milk Milk Loss	Early Culling Loss	Repro Loss	Milk, Early Culling & Repro Losses/Case*	Incidence
Lactation = 1	Early Mastitis	($164)	($97)	($27)	($288)	4.5%
	Metritis	($114)	($9)	($99)	($222)	22%
	RP	($157)	($19)	($149)	($325)	4%
	DA	($413)	($130)	($82)	($625)	0.9%
	Any Early Disease	($109)	($35)	($52)	($196)	42%
Lactation > 1	Early Mastitis	($243)	($79)	($42)	($365)	6.4%
	Metritis	($188)	($22)	($129)	($340)	12.7%
	RP	($124)	($11)	($156)	($291)	7.2%
	DA	($453)	($130)	($77)	($660)	3.4%
	Any Early Disease	($180)	($66)	($82)	($327)	38%

These losses are based on dairy-reported disease incidence and do NOT include labor, treatment, or veterinary services costs. Also, culling losses were considered only through 60 DIM.

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Even the Best Economic Models are Severely Limited in Utility if the Input Data are Inconsistent or Inaccurate

- Disease records are extremely variable. Inconsistencies may preclude us from making faster advances in
  - understanding the impact of disease on cow performance
  - understanding the relationship between diseases
  - rate of genetic progress
- What if the disease definition used was different?
- What if the detection approach used was different?
- What if the herd inconsistently recorded it?
- It is CRITICAL that we work towards more consistent disease definitions, detection and recording
  - Disease treatment protocols with standardized recording can really help this effort

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Management in the The Vital 90™ Days is Critical: *RISK, COSTS, and* ***OPPORTUNITY***

- Opportunity:
  - With improved risk management and disease prevention efforts during The Vital 90 Days…
    - Reduced disease incidence
    - Lower treatment costs
    - Reduced mortality and culling
    - Higher milk production throughout lactation
    - Opportunity for improved reproductive performance
  - Healthier transition cows = greater profit potential
- Better disease information (more accurate and complete records) could help our efforts towards healthier transition cows

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Summary

- The RISK of disease is very high during The Vital 90 Days
- The COST of both clinical and subclinical disease is often higher than we might imagine
  - We often are unaware of the magnitude of the opportunity costs of disease
  - With incomplete disease records, the *apparent* impact is less than the *true* impact
- Consequently, there is a huge OPPORTUNITY for most dairies to improve performance and profitability
  - Improvements in disease detection, recording and interpretation of records can help accelerate our progress

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Thanks For Your Attention!

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New Concepts in Ventilation to Keep Your Cows Comfortable

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Introduction
Annual losses to the US dairy industry due to heat stress exceed 900 million dollars. Reducing thermal stress is a key issue in efficient and profitable dairy production. Across the US there has been tremendous improvement in heat stress abatement for dairy cattle in the last two decades. However, heat abatement systems continue to evolve and develop, increasing the choices available to dairy producers. Systems today focus on providing adequate cooling while minimizing energy and water utilization. In addition, the benefits of cooling dry and pre-fresh cattle have also been addressed in several studies. The key benefits of effective cow cooling are increased milk production, increased feed intake and improved reproductive performance. Improvement in summertime milk production and reproductive performance has longer-lasting effects than just a few summer months. Effective heat abatement during the summer, which allows for normal pregnancy rates, reduces the slugs of pregnancies in the fall, which generally results in increased calving activity in the spring and early summer. The focus of this paper will be some of the newer options available to dairy producers for effectively cooling their dairy herds.

Determining Thermal Stress
Thermal stress in dairy cattle is most often defined by the Temperature Humidity Index (THI). Most recently, researchers at the University of Arizona have redefined this index with more current dairy genetics. This index combines the effects of temperature and humidity into a single estimate of thermal heat load. The data suggested that milk production losses began when the minimum daily THI exceeded 65 or when the average THI exceeded 68. In general, the industry has accepted that heat abatement should begin when the THI reaches 68; however, losses started at a THI of 65.

The effects of heat stress and mechanics of heat exchange were extensively studied at the Missouri experiment station in the 1940s and 1950s. Studies showed that at temperatures above 70°F, heat loss was primarily due to moisture evaporation from the skin and lungs. As temperatures exceeded 90°F, more than 85% of the total heat dissipation was due to vaporization of water from the body surface and lungs. Researchers suggested that at a temperature of 95°F, wetting the hair and skin greatly increased heat dissipation due to the hair increasing the surface area available for water vaporization.

Experimentally, respiration rate, body temperature and heart rate have been measured as indicators of increased thermal stress. There has been considerable interest in developing a system by which sentinel cows would be monitored and the data utilized to control heat abatement systems. While this would offer more precise control of the system, the concept has not been widely adopted in the industry due to issues of cost and reliability.

Methods to Reduce Thermal Stress
Lactating dairy cattle produce large amounts of heat due to digestion and metabolic processes, and this heat must be exchanged with the environment to maintain normal body temperature. Cattle exchange heat through the mechanisms of convection, conduction, evaporation and radiation. Cattle can either give or receive heat energy from the environment. Solar radiation increases heat load by increasing the surface temperature of cattle. Air temperature above the normal body temperature of cattle also increases the heat load. In addition to increasing heat load, heat exchange at the body surface is reduced. Protection from solar radiation by providing adequate shade is the first step in reducing heat stress in dairy cattle.

Increasing natural ventilation during the summer months by increasing sidewall openings, increasing roof pitch and providing an opening at the roof peak have been incorporated into building designs for many years. Many existing facilities have been modified in an effort to increase airflow over the animals. However, this does not effectively address the situations where thermal stress exceeds the natural ability of the cow to exchange heat with the environment. For the months of May-September, this can be a huge challenge for Midwest dairy producers.

Feedline Soaking
For the last couple of decades, the application of feedline soaking systems and supplemental airflow

created by fans has been a popular method to reduce heat stress in dairy herds. By starting with increased air movement and then increasing the amount of water applied as heat stress increases, producers have been able to reduce the level of heat stress experienced by the herd. Wetting frequency and level of supplemental airflow have been shown to have a dramatic impact upon the heat exchange rate of dairy cattle. Systems have been shown to be effective in increasing summer milk production and have proven to be economical. However, in some cases water consumption and the efficiency of wetting have been a concern. In general, most systems will only utilize about 25% of the consumed water for cow wetting. Most of the rest will simply increase the volume of waste in the lagoon.

Increasing Airflow

There has been considerable research completed to address the speed and where airflow should be increased in a dairy barn. The first place would be the milking parlor holding pen. Generally, an air speed of 7 to 8 MPH is sufficient for effective cow cooling. However, in areas such as the milking parlor holding pen, it is important to introduce fresh air into the space as well. Some designs do not effectively introduce fresh air and only circulate the existing air. When trying to evaporate water from the backs of cattle, it is important to provide for adequate air exchange as well as air speed. Opening the sidewalls and including a roof peak opening will help with air exchange. However, this may not be adequate. Newer designs incorporating mechanical ventilation are addressed later in the paper.

Air Exchange Rate

Providing adequate air exchange is very important. During the wintertime, an air exchange 4 times per hour is considered adequate. However, during the summer, some systems may have exchange rates as great as once per minute or 60 times per hour. Generally, the ventilation rate has been increased to this level to increase the airflow over the animals and not because the ventilation rate needs to be once per minute. When ventilation rates are this high, it may be difficult to effectively use evaporative cooling to cool the air to reduce the heat stress in the building due to the volume of air that must be cooled at greater ventilation rates.

Increases in Fan Efficiency

New fan motor and fan blade designs have resulted in improvement in fan efficiency as determined by electrical usage per unit of air moved. In many cases, fans today are 25 to 30% more efficient than older standard basket fans. While these fans are more expensive, they are also more energy efficient and can help reduce operational cost in new and remodeled dairy facilities. In many regions, rebates from electrical supplies may help offset the additional cost of energy-efficient fans. Dairy producers are encouraged to carefully review the energy efficiency data when choosing fans. There are many choices available today, so make sure you understand the efficiency of the fan being purchased.

Adoption of Variable Speed Drives

Traditionally, fans were either on or off. Increasing the amount of airflow was simply a matter of increasing the number of fans running at a given time. Today, each fan can be equipped with a variable speed drive which allows for various fan speeds and also the ability to reverse the direction of rotation for winter time ventilation or mixing of the air in a facility. These drives can be utilized on fans operating on the intake and exhaust, and for air mixing within the buildings. Fans can be controlled to gradually increase airflow and air exchanges as heat stress increases to create a more uniform air flow across the building. This should improve air quality as well as more effectively reducing heat stress. This can also greatly increase the efficiency of electrical usages as the watts consumed per unit of air moved improves when the fan is turning at less than 100% of motor capacity. The cost of operating more fans at a lower speed may be less than operating a few fans at full capacity. Operating more fans at a lower speed will also improve the uniformity of the airflow across the building.

Changes in Sensors

One of the most exciting changes in cow cooling is from the standpoint of sensors for relative humidity. For many years, there has been a struggle to find relative humidity sensors which would work in the dusty and humid environments found in dairy facilities. Temperature sensors were generally reliable and durable. Humidity sensors required frequent maintenance and calibration to function correctly. The changes in humidity sensor design has greatly improved accuracy and durability. Now, relative humidity can be used efficiently and effectively to determine the level of heat stress experienced by cattle and to operate cooling systems to cool cows more effectively. This is especially important when using high-pressure misting or evaporative cooling to cool the air of the housing environment.

Changes in Cooling Controls

Significant advances have been made with cooling system controls. With the availability of improved humidity sensors, combining measurement of temperature and relative humidity into cooling system operation functions is becoming more commonplace.

This is especially true when using high-pressure misting for evaporative cooling of the air. The combination of sensors and advanced controls has allowed engineers to reduce the issues of creating a condensing environment, resulting in wet equipment and bedding when evaporative cooling is combined with increased air velocity.

Changes in Barn Designs

Over the past couple of decades, we have moved from naturally ventilated barn designs toward tunnel-, cross- and positive-pressure designs for heat abatement in free stall barns, milking parlors and milking parlor holding pens. Tunnel- and cross-ventilation designs have been utilized to improve the airflow over the cattle beds. Cow behavior resulting in lying times of greater than 12 hours per day has been shown to increase milk production. Many barn designs contain a multitude of fans which control air entering the building, exiting the building and mixing within the building. By reducing the intake and exhaust airflow to the amount needed for fresh air exchange and then utilizing mixing fans internally to create the airflow over the beds, total energy utilization can be reduced as compared to simply increasing exhaust fans to create appropriate air velocity throughout the building. Utilizing positive pressure to introduce fresh air into the building also reduces the static pressure of exhaust fans. This also results in greater energy efficiency of the exhaust fans.

Advances in Evaporative Cooling

Soaking and then evaporating water from the surface of cattle represents the most efficient method to remove heat from cattle. However, when environmental temperature exceeds cow body temperature, evaporative cooling of the air may be necessary. Air conditioning would be the most effective by reducing air temperature and relative humidity. However, due to energy costs and system maintenance issues, it is not considered as a practical solution on commercial dairies.

A possible solution is evaporation of water into air as it enters the cow facility. Combinations of tunnel ventilation and evaporative cooling have been used in swine and poultry operations for many years to cool the environment. Recently, these systems have been installed in some Midwest dairy facilities. Many research reports have demonstrated that evaporative cooling can reduce the total hours of higher levels of THI in some environments. Evaporative cooling has been used very successfully to cool dairy cattle in hot arid climates. Under arid conditions and high environmental temperatures, the potential to reduce temperature and THI is improved. However, as relative humidity increases and or temperature decreases, effectiveness of evaporative cooling to modify the environment decreases. As relative humidity increases above 70%, the potential reduction in THI is less than 10%.

The improvement in controls, sensors and application of variable degrees of high-pressure misting have resulted in more robust systems that more effectively reduce the heat stress of dairy facilities. These improvements come with significant cost and are generally only effective in arid environments where several months of heat abatement is required.

Cooling the Bed

A newer concept of heat abatement involves cooling the freestall bed with various types of cooling systems. This creates a cooler surface for the cow when lying and helps to address the need to cool in the area of the barn where the cow will spend the largest portion of the day. It may also entice the cow to lay in the stall for a greater period of time. Systems have employed a variety of cooling lines and types of coolant. The depth and type of bedding seem to have major impacts on the degree of cow cooling. In very stressful environments, the heat balance may be positive and the cow's body temperature may rise to the point at which standing is more comfortable than reclining. In this case, an additional cooling system would need to be utilized to address the standing cattle.

Summary

Many changes have occurred in the last 10 years with the equipment and heat abatement systems available to dairy producers. While the changes are significant, the basic requirements of heat abatement are still the same. The goal should be to increase the amount of heat the cow can exchange with the environment. When thermal balance is no longer attainable, body temperature will increase resulting in many negative effects, most notably, losses of milk production and reproductive efficiency. Complex systems which control the environment of the cow through fresh air induction, air movement, evaporative cooling and exhaust ventilation and produce a more controlled environment for cattle can result in an improved environment for cattle. However, the cost of complex systems may be greater than the return in increased milk production. In additional to heat abatement, other factors of cow comfort and nutrition must be considered in order to get the maximum benefit from the system.

Considerations in Choosing Cooling Systems

1. Shade the cow from solar radiation. This should always be the first step in any cooling system.
2. Consider average temperature and relative hu-

midity of location during each hour of the day. Determine when during the day evaporative cooling would be effective. Even in humid environments, afternoon humidity may be low enough to benefit from evaporative cooling.

3. If environmental temperature is near or above normal cow body temperature for a significant portion of the summer, some form of evaporative cooling will likely benefit your operation.
4. Do not depend upon evaporative cooling alone, except in very arid environments. In most environments, feed line soaking will provide cooling over and above the evaporative system.
5. Consider all costs associated with evaporative cooling and feed line soaking. While additional benefits are realized by combination systems, additional milk production may not offset expenses.
6. When pricing and comparing different cooling systems, carefully consider all the options of the various cooling systems and make sure you are pricing comparing similar equipment.
7. Consider not only airflow, but also air exchange when selecting a cooling system for the entire year.

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Management Strategies During Challenging Times

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Management strategies during challenging times

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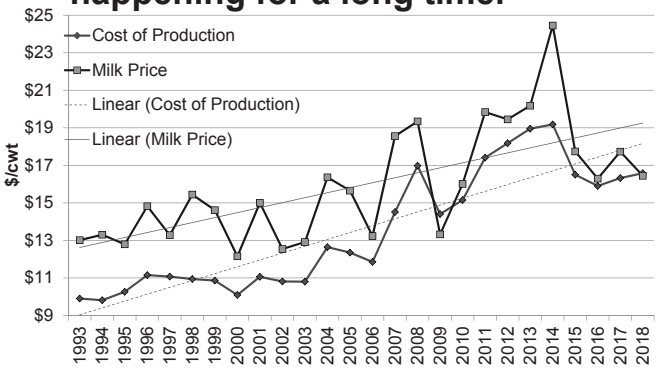
1

Margin compression has been happening for a long time.



Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

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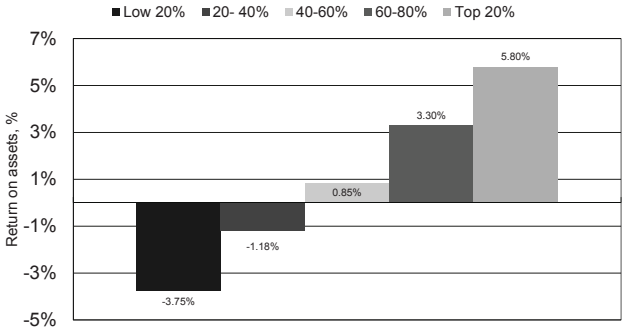
Return on assets for Midwest dairy farms in 2015-2018



Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

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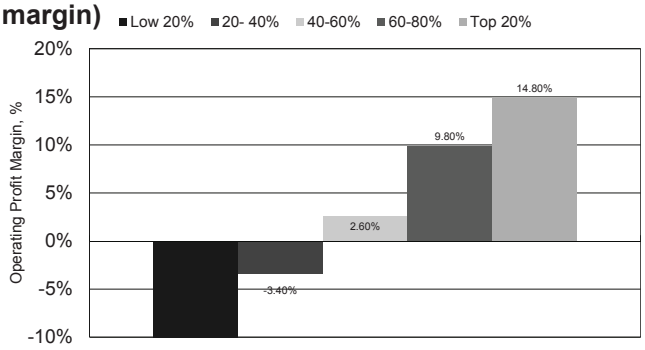
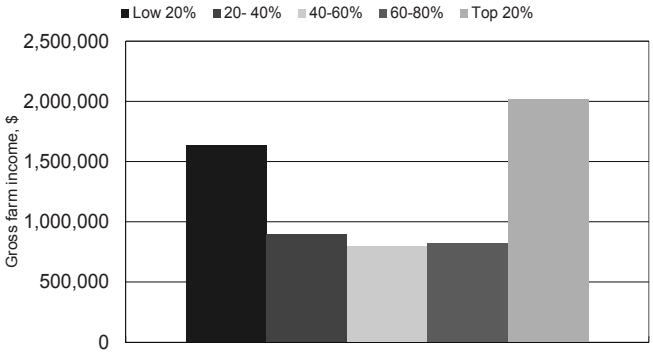
High profit farms keep a higher percent of every dollar of income!!! (Operating profit margin)



Data from 2015-2018
Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

UNIVERSITY OF MINNESOTA | EXTENSION 4

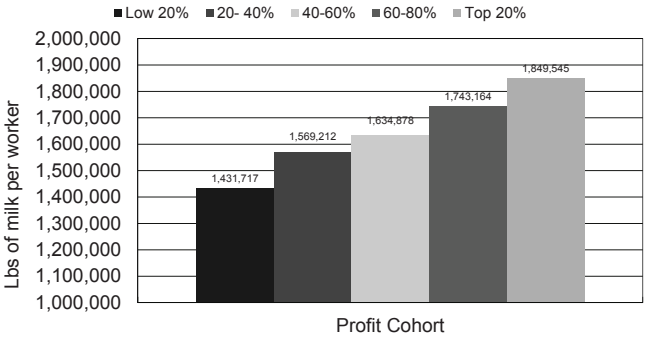
Large farms tend to be the most and least profitable farms.



Data from 2015-2018
Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

UNIVERSITY OF MINNESOTA | EXTENSION 5

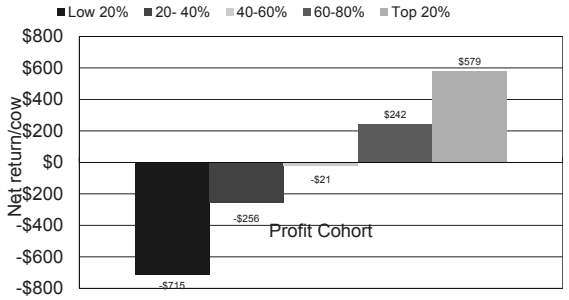
High profit herds sell more milk per worker



Data from 2015-2018
Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

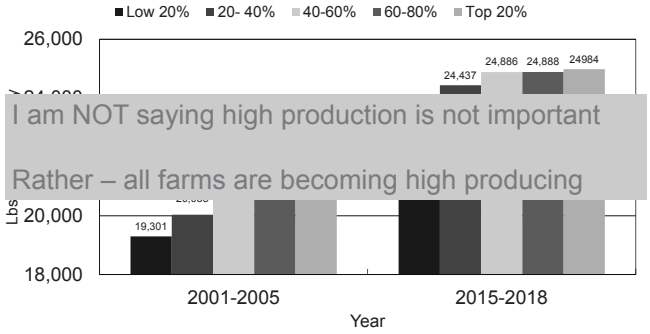
UNIVERSITY OF MINNESOTA | EXTENSION 6

Net return per cow was negative for three cohorts in 2018



Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

Has pounds of milk per cow become less important to maximize profit?

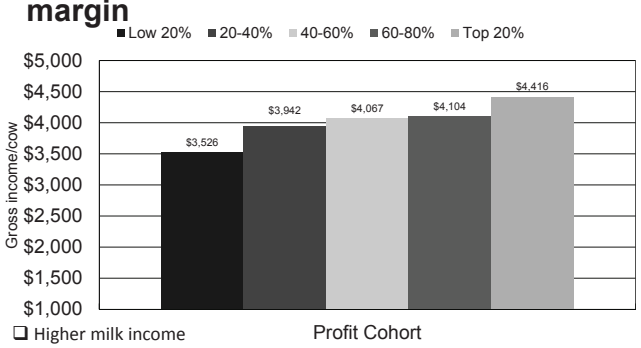


I am NOT saying high production is not important

Rather – all farms are becoming high producing

Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

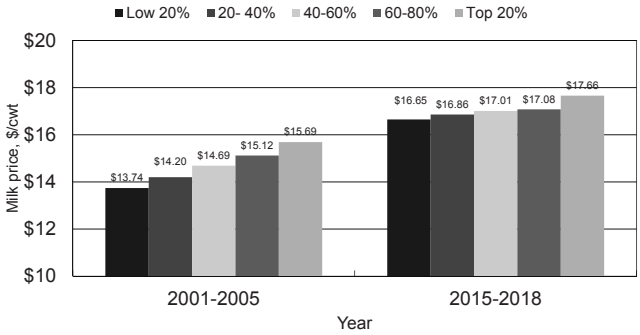
High profit farms have higher gross margin



- ❑ Higher milk income
- ❑ Lower net replacement costs

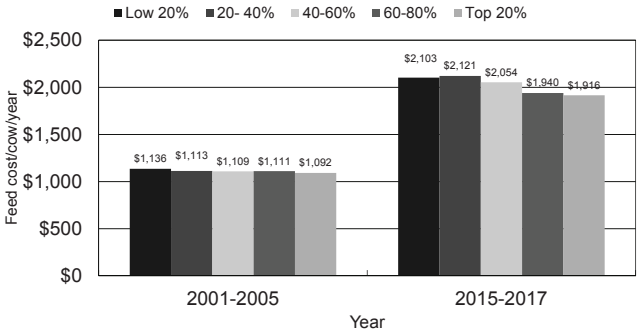
Data from 2015-2018
Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

Higher profit farms produce higher value milk



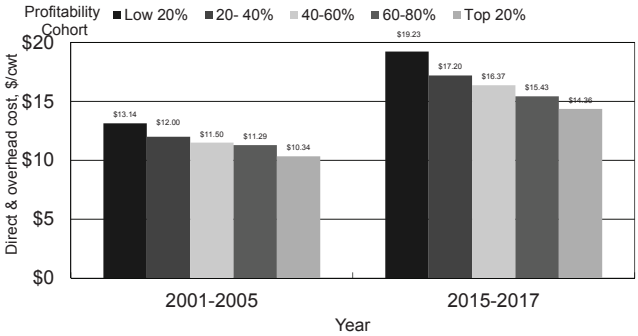
Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

High profit farms have lower feed cost



Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

High profit farms do a better job of controlling all costs



Data source: FINBIN (2019). Center for Farm Financial Management: University of Minnesota. Retrieved from http://finbin.umn.edu

Have the rules for profit changed?

- 1960's - Focus: Hard work
- 1980's – Focus: High quality forage
- 1990's – Focus: Milk quality
- 2000's – Focus Cow comfort
- 2010's – Focus: Reproduction

Future profit: Will it be driven by efficiencies?
Labor: (Family and hired)

- Moving to a knowledge/tech based economy

Business acumen/Asset use

What will be your strategy?

Every farm has one…. even if you don't know it.

- Be the best?
- Diversify?
- Be more nimble?
- Value added?

Staying the same is likely not an option

Scale-adapted Dairies

- Herd sizes in excess of 1200 cows??
- Freestalls, TMRs, parlors
- Often contract forage production and heifer rearing
- Significant hired labor force
- Intend to compete by economies of scale and volume in the face of tightening margins
- Must be good at labor management

Traditional Dairies

- Less than 600 cows? (most smaller than 200 cows)
- Owner/family managed
- Multifamily or some hired labor
- Forage production and some grain or cash crops
- Intend to compete from an established base of facilities and equity
- Must be good at asset use
- What is your strategic advantage?

Need to have high margins per cow

Niche-adapted Dairies

Have found a specialty niche that sets them apart from most dairies, for example:

Grazing
- Suitable land base
- Low cost of production
- Advantage with increasing input costs??

On farm processing
Organic
Specialty markets (e.g. sale of genetics)

Intend to compete by significantly expanding the margin between income and expenses

Jim Salfer
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Management Strategies During Challenging Times

Jennifer Bentley
ISUEO - Dairy Field Specialist
jbentley@iastate.edu

Management Strategies During Challenging Times

- Calf & Heifer
- Reproduction
- Transition Cow
- Milk & Components
- Feed & Forage Mgt.
- Maximize Labor

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Jennifer Bentley
ISUEO - Dairy Field Specialist
jbentley@iastate.edu, **563-382-2949**

Colostrum: More than just antibodies…

- **Single most important management factor for calf health and survival**
- Quality = >50 g/L IgG
  - 150-200 grams of IgG at 1st feeding
  - Rich 1st source of nutrients
- Quantity - 10-15% of birth weight
- Quickness - within 2-4 hours
- sQueaky clean - <100,000 cfu/ml

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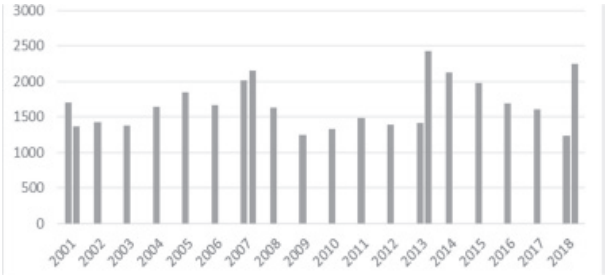
Calf & Heifer Program - Investment or Cost?



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Reproductive Goals

- **Pregnancy rate: >22%**
  - Cow inseminated within 21 of end of VWP>90%
  - Heat detection rate >65%
  - Conception rate: >35%
  - Cow pregnant by 150 DIM: >70%
- **Lactating herd confirmed pregnant: >50%**
- **Cows culled for reproduction: <5%**
- **Age at first calving: 22-24 months**

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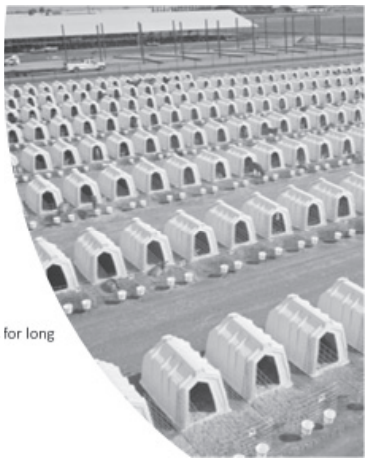
Managing Heifer Inventory



- What is being generated?
  - Excess Heifers?
  - Impact of Overcrowding
- How many are needed?
  - Sexed vs Conventional
  - Genomic Testing
    - Identify heifers with desired genetics for long term viability in the herd
  - Consider beef
- KPI's to watch for….
  - % DOA and HFR Ratio
  - Double Birthweight in 56 days
  - Age at 1st Breeding and Age at Calving

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Reproductive Goals

- **Know when to stop breeding**
- If 3rd lactation and "deviation from herdmates" milk is negative after 1st breeding consider "Do Not Breed"(DNB).
- If average cow, consider DNB after 2 services.
- 3-4 breedings should be the limit for the majority of cows. An exceptional cow may get more breedings.
- If a cow loses a pregnancy and is over 200 DIM then she should be on the DNB list.
- Consider Somatic Cell Count(SCC), Lameness and Other Factors

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Reproductive Goals

- **Increase number of calves born**
  - Increasing heifer calves augments the dairy's flexibility in culling decisions
  - Increasing bull calves improves income, as increasing heifer calves allows greater flexibility in culling decisions.
  - Role of genomic testing
- **Lower culling rate**
- Culling for reproductive reasons is the single-highest reason cows leave the herd.
- Reducing the amount of cows culled for reproductive reasons, will allow culling for low production.

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Heat Stress affects Dry Cows too!

Heat stress conditions at **conception** or **late gestation** reduces daughter milk production

Lower birth weights and compromised transfer of immunity compromised calves heat stressed in utero

Cooling cows during late gestation effective to lessen impacts of heat stress on calves

Transition Cow Program -
Single most impact on peak milk

- <30 DIM: 4% culled
- <60 DIM: 6% culled

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Milk Quality (SCC) AND Components!

Pounds of components produced vs. pounds of milk produced, what are you getting paid for??

- SCC < 150-200,000
- New infections (high SCC) < 5%
- Clinical mastitis / mo. < 2%
- % 1st lact. < 200,000 ≥ 90%
- % older cows < 200,000 ≥ 80%
- % early lact. > 200,000 < 10%
- % culled for mastitis: < 8%?

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Transition Cow Facility Goals:

✓Maximize dry matter intake:
- 18-24 inches to dry cows
- 24 inches to milking cows
- 30-36 inches to pre/post fresh cows.

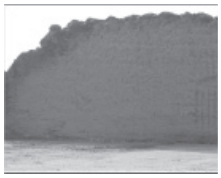
✓If working with existing facilities, priority should be given to feed access

✓80% stocking density if pre/post fresh cows have feed access of 24 inches

✓100% stocking density if pre/post fresh cows have feed access greater than 30 inches

Feed & Forage Management

- **Maintain Forage Quality**
  - Harvest corn silage at the right moisture content
  - Properly cover bunkers and drive-over piles after packing
  - Keep an even face
  - Remove moldy feed
  - Monitor dry matter content at least weekly
- **Ration formulation vs. ration formulation**
  - Chop length, mixing of ingredients, inaccurate weighing



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Maximize Labor

- "Train people well enough so they can leave, treat them well enough so they don't want to."
- Increasing cost of labor.
- Second greatest expense – just behind feed expense.
- Increased labor productivity = Increased cow productivity.

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Reference: Melissa O'Rourke, ISUEO Farm and Agribusiness Management Specialist

What is Turnover Costing You?

- Estimates are 150 to 250 percent of an employee's annual wage.
- Employee making $10-12/hour
- Turnover cost = $37,500 to $45,000 at 150%
  - Example:
    - 20 employees and 10% turnover….
      - Cost = $75,000 to $90,000 per year
- Important concepts to consider:
  - Importance of job analysis and descriptions
  - Recruitment and selection considerations
  - Orientation and onboarding

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Reference: Melissa O'Rourke, ISUEO Farm and Agribusiness Management Specialist

A Farm Stress Resource Package

Larry Tranel, Psy.D.
Dairy Specialist
NE/SE Iowa

Jenn Bentley
Dairy Specialist
NE Iowa

A Farm Stress Resource Package

1. Farm Market Reality, Stress and Grief
2. A "PRIMER" on Farm Stress Resiliency
3. Keys When "Married" to Farm Stress
4. From One Dairy Girl to the Next
5. Helping Farm Men Under Crisis!
6. Farm Youth Stress and Challenges
7. Good Grief, We Just Lost…!!!

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Jenn Bentley
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NE Iowa

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Farm Market Reality, Stress and Grief

Farm market stress and grief gave cause feelings of being overwhelmed, depressed, immobilized, lack of energy, loss of hope, etc. This can lead to exhibits of anxiety, anger, tears and loss of good decision-making ability.

With market stress and grief, people often wonder—What can I do to get out of this mess or be able to save the lifestyle and assets?

It is important to recognize when to seek help and make informed decisions, not out of confusion and emotion, but objective reality, even when confusion and emotions are running high!

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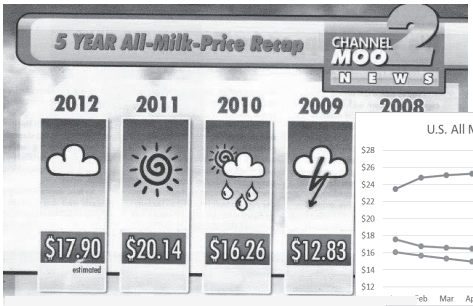
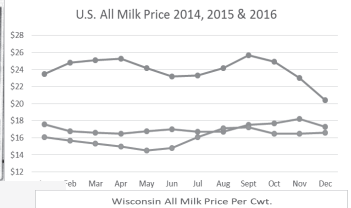
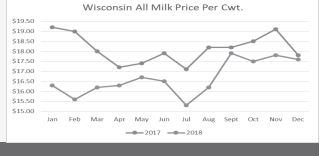


Happiness Often Just a Matter of Perception



Farm Happiness Index
Weather or Prices Make Day?

Difference affects the Kids!
+ or – TRANSFERENCE



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Farm Market Reality, Stress and Grief

Dairying Might Get Even Tougher in Reality as markets change. Exports might not clear additional milk and processing capacity sees constraints. Markets are not always humane--providing a price point to balance supply and demand, even if low. Benefits of a free market do not come without cost.

A sad reality is the probability of an extended dairy recession even worse than the past.

Somebody or something needs to clear the market, meaning producers continue to leave. Who will it be or what will move the milk?

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Farm Market Reality, Stress and Grief

Market Reality is an understanding of past market cycles, current market forces and future market opportunities based on a complex set of economic, political, cultural and other situations that affect farm incomes at any given point in time. **Reality is the Future is UNCERTAIN!**

Market Stress is an extended time where low product prices or high input costs cause negative margins and/or negative cash flow.

Market Grief is a reaction to the loss of something (profit or way of life) that is loved and cherished because finances or cash flow do not work out for extended periods of time.

Asset Values
Product Prices
Input Costs

"Holy Cow! What Do I Do Now?"

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Farm Market Reality, Stress and Grief

Making the Tough Choices and Seeking Marketing Options—while many producers do not use a risk management tool, they are available and can be useful. For example, the 2018 Farm Bill gives dairy producers new market protection options, Dairy Margin Coverage Program (DMC) which, in reality, may actually protect the over-supply of milk.

Options? Processing capacity sees constraints, marketing to other processors or going Organic, Grass-Milk, A2, on-farm processing….?

Farmers need to be resourceful when considering how else resources can be used. Farm alternatives or off-farm jobs might not be a great choice, but a possibility needing consideration.

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Farm Market Reality, Stress and Grief

Every farm needs an operating plan, and as important, an exit strategy-setting a point where one is no-longer willing to accept equity loss and will exit the industry or reallocate resources to another enterprise. The easiest route, is to do nothing and hope things resolve themselves. Unfortunately, that hardly ever works.

There is life after the cows leave the barn or even after people leave the farm. It is a tough reality, filled with stress and maybe even grief, but is often a necessary outcome in times of trouble.

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*The **problem in life** is not that there are problems.*
*The problem is expecting life without problems, thinking that having a problem is a problem. That, my friends, so often becomes the problem. Know, that overcoming problems transforms and builds us into becoming more than before. Thus, problems often ignite more wholeness in us, which is why **having a problem isn't always a problem**. -- Larry Tranel*

Farm Market Reality, Stress and Grief

***Hopefully*, all the market reality, stress and grief can be worked through**: making tough choices; reaching out to others, exploring options and giving life a new reality, whatever that might be.

Hopefully*, *a new acceptance is attained that gives hope to meaningful life—a life maybe just different than before.

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A "PRIMER" on Farm Stress Resiliency

Farming is dangerous and stressful. Farmers have varying degrees of resiliency to stress to deal with the physical and mental dangers of farming. The integrated blend of family, farming and nature can cause unique situations of stress in farm families.

Stress is normal and can be healthy as it might push us to do things that can promote growth in us. But, too much acute stress or piled up chronic stress makes it difficult to:

- Concentrate, remember and process information.
- Organize, calculate and make decisions
- Sleep, relax and breathe properly
- Communicate, share and bond as a family.

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Chronic farm stress can weaken a person's spirit, appetite, physical stamina, focus, relationships, decision-making ability and dampen happiness and satisfaction in time. Life skills can help deal with it.

A "PRIMER" on Farm Stress Resiliency

Resiliency can be a learned, life skill.

Perception – Our Thoughts under Stress
Reality – Our Environment in Stress
Identify – Our Emotions with Stress
Manage – Our Reaction to Stress
Extend – Our Communication of Stress
Resources – Our Support for Stress

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A "PRIMER" on Farm Stress Resiliency

Stress can become a source of conflict BUT, can also help families grow together as many farm families are strong ***because*** they had gone through a tough time together.

There are **smaller** amounts of "MARGIN" in both time and finances in addition to other internal and external forces in farm families.

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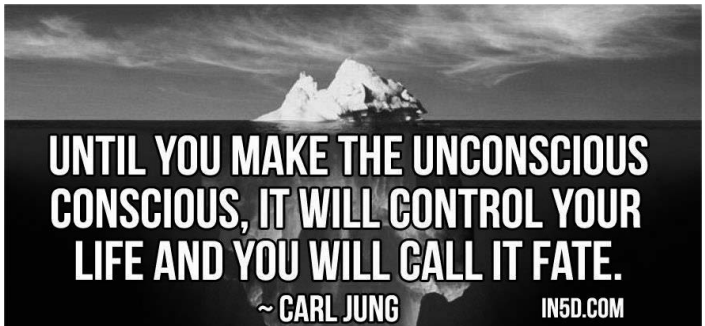

With Stress know what you can control and what you can't.
Accept what you cannot control, even if unfair,
An unforgiving spirit can add greatly to stress
Maintaining sense of control, even small, can make the difference!

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A "PRIMER" on Farm Stress Resiliency

Too much stress can lead to anxiety, doubt, depression and hopelessness. **Chronic stress can shorten brain receptors/nerve endings**. Overcoming stress overload by developing skills can help families have more resiliency to farm stress.

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A "PRIMER" Perception

Families who **reinterpret** initial negative to more ***positive meanings*** of their overall crisis situations, are more likely to be in control of their stressors, to **find possible solutions** to crisis situations, and to **adapt well** eventually to the crisis (Xu, 2007). **Again, The problem is not that there are problems or stress, the problem is expecting otherwise and thinking that having a problem is a problem.**

Seeing stress as normal and a means of growth is a great tool. Accepting that **life is difficult** at times and that it is in the **process of overcoming difficulty that gives life some of its meaning** by helping us to grow is often an attitude that can assist more positive perception of stressful situations.

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A "PRIMER" Perception

Perception is heavily related to the image or picture we have in our minds of whatever situation, coupled with any meaning, emotion or attitude attached to that image or picture.

An occurrence might happen to two people and one might very positively perceive it and the other very negatively with a wide range of other "perceptions" in between.

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Resilient people don't have less stress—Deal with it better!

Physical – 1. Eating and Exercising Well, Feeling Healthy
2. Tired/Unmotivated/Junk Food attraction/Trouble Relaxing
3. Exhausted/Binge Eating-Drinking/Aching
4. Sleeplessness/Chronic Aches/Feel Sick/Can't Get Out of Bed

Mental— 1. Focused, Creative and Good Concentration
2. Procrastinating/Worries/Avoiding Tasks/Forgetful
3. Negative/Preoccupied/Difficulty Making Routine Decisions
4. Impaired Decision-making/Judgement/Suicidal Thoughts

Emotional—1. Propensity to Smile/Excited/Motivated to Do-Help
2. Impatient/Irritable/Discouraged
3. Anxious, Overwhelmed, Exasperated, "Peopled Out"
4. Don't Care/Lack Hope or Help/Burdened/Social Isolation

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10 Pt Scale – Add Each Category Level = 3-12
=3 Great; 4-6 Stressed; 7-9 Get Help; >9 Need Help!

Resilient People More Proactive, Less Reactive or Passive!

Proactive—Try to Control What They Can:	Reactive—Influenced by Others and Environment	Passive—Wait for Things to Resolve on Own:
Plan, Rather than Hope	Blame—Victim Mentality	Hope, Rather Than Plan
I plan to…	I can't help being…	If you want…
I decided to…	I am not happy because…	Things will work themselves out…
I am looking into…	If only he/she would have…	I'd like to but…
I want to…	I don't know why I….	It's not my decision…
I will…	My ____ made me do it….	Someday it might change for the better..
I am going to….	It's just the way it is….	

Resilient People Do Something About -Situations

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A "PRIMER" Identify

Identify emotions--so intertwined and often mangled that identifying the underlying causes or emotion is not easy.

Anger, a secondary emotion, often is expressed due to another emotion. Anxiety and depression often have a root cause. Look inward to identify causes so as not to transfer negative emotions to or onto others.

When angry, it might be easiest to transfer the cause to the person closest to us, a spouse for instance, since they were part of the environment when the situation occurred, though they were not the source. IDENTIFY and **Do Not** TRANSFER!

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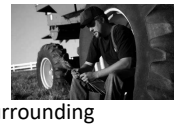
A "PRIMER" Reality



Reality is a sum of a person's internal capacity and external environment to understand the situation surrounding stress or a crisis event. Some situations take families by surprise or are beyond their control. If life events come too soon, are delayed or fail to materialize, the health, happiness, and well-being may be affected (Schlossberg, et. al., 1996).

So, the reality of farm and family stress can be normal living or it can cause many physical, mental, personal and family ailments. The goal is to understand the reality of the stress environment and seek remedy. Even when faced with same situation, we each have our own reality.

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A "PRIMER" Identify

The goal is positive emotions regarding stressful and other situations. Situations exhibit chemical reactions in our bodies that trigger our emotions. Our brains label the experience as good, bad, happy or sad, etc. It's a mind over matter deal as positive thoughts are a precursor to positive feelings or emotions.

So, the skill to learn is how to identify emotions that have occurred while thinking positive thoughts. Thus, we are about as happy as we make up our minds to be. Choose happy and return there even when life gets us down, though granted, easier said than done.

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A "PRIMER" Reality

What We THINK will make us Happy, often doesn't give true JOY!

Thoughts of getting a new Tractor, a better milk price, a new home, better cows, a cooler car, keeping up with the Jones…..

1) Once we get it, we often find that it was the thought of it, not getting it, that gave a perception of happiness but in reality we find out that wasn't so.
2) If we don't get it, we often play the blame game—life isn't fair, I should have gotten it and spend our lives thinking, if only, if only I would have…, my life would have been so much better.

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A "PRIMER" Manage

Manage through stress knowing all situations have some hope, alternatives or options. Identify what can be controlled and accept what is beyond control without blaming oneself. Understand that lack of clarity of future can induce stress as it brings worry, confusion, conflict and even shame (Boss).

Assess stress symptoms--heart rate, shallow breathing, headaches, anxiety, outbursts, lack of focus and hope to name a few—to know stress levels. *Use the "**BEE SET**" tool to take the **STING** out of stress.*

☺ **The Best Place to "BEE" is Together,**
so "SET" your stress straight. ☺

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A "PRIMER" Manage

"BEE SET" —Breathe, Exercise, Eat, Sublime, Express, Talk

Breathe deep, not shallow, using stomach breathing, slow and draw out, to get more oxygen to the brain for better decision-making.

Exercise to heart pumping levels to increase blood and oxygen flow
Eat healthy to feel better.

Sublime, or trade pain, using visual thinking of happy times and places to relax mindset and change thoughts for a while.

Express acceptance of the reality of the situation to help focus on a response or solution instead of the problem.

Talk yourself through felt emotions with positive "I can do this" attitude, coupled with breathing, exercise, and subliming activities.

Serotonin…neurotransmitter…contributor to feelings of well-being and happiness…modulating cognition, reward, learning, memory, physiological processes.

5 Simple Ways to Boost Serotonin *by Georges Sabongui @ 2018*

1. **Sleep**—Melatonin is transformed into Serotonin. Lack of sleep causes overstimulation of amygdala (more emotional) and understimulation of left frontal cortex (rationality)
2. **Smile**—those even forced to smile report feeling happier—pencil b/w teeth ☺
3. **Sports**—exercise 7 minutes with 160 beats/minutes—point of exhaustion is ideal for brain. In anaerobic zone, body burns protein to manufacture serotonin.

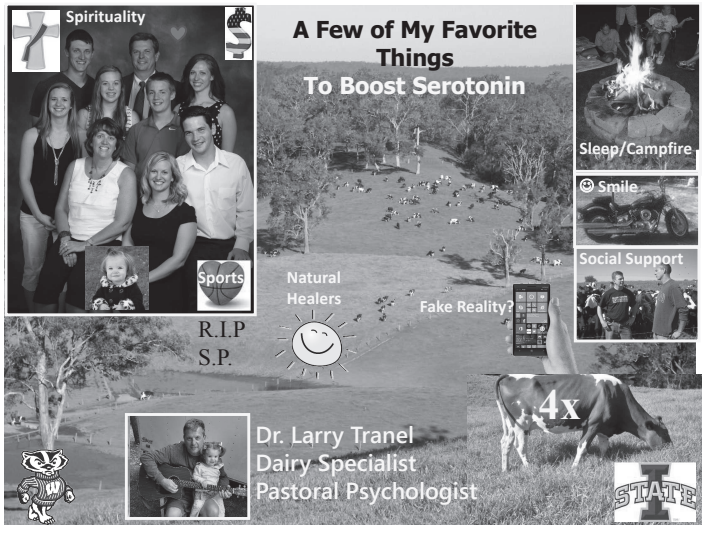
4. **Social Contact**—people with broader social network, not talking twitter and facebook, secrete more serotonin and are more resilient dealing with stress. Lack of social support can reduce life expectancy 10-15 years (loneliness eq. of 15 cigs/day)
5. **Spirituality**—connection to something bigger than ourselves. Research shows people with strong spiritual practice are happier than others.
6. . **Diet—**Foods that contain tryptophan can increase serotonin levels include eggs, dairy, poultry, nuts, salmon, tofu (soy), spinach, seeds, and pineapple.

A "PRIMER" Extend

Extend oneself to others as social isolation and loneliness can further add to stress. Those in family environments are best helped by family members, but introverted males often do not extend their thoughts and feelings readily to allow for healthy family support. Guilt, shame and social stigma often inhibit extending to others for help, as well.

Feeling close to others increases oxytocin in the blood. Doing things for others increases happiness and reduces focus on self and personal problems—a subliming tactic!

Force oneself to find things to smile and laugh about—laughter being the best medicine is more than a metaphor! ☺



A "PRIMER" Extend

Difficulty is a common part of life, so realize one is not alone. Lack of social support can be a cause of future depression and loss of hope.

The goal is to become more intertwined in other's lives.

Stressed people are often better helped by family and friends who care than even by trained counselors.

When extending to others, we often find new perspectives and mindsets, not to mention better feelings of the stressful situations at hand and experience a basic human need of compassion.

What causes Serotonin Deficiency?

1. **Prolonged periods of stress**. Farming, fast paced, fast food society.
2. **Genetic factors, faulty metabolism, and digestive issues** can impair absorption and breakdown of food reducing ability to build serotonin.
3. **Poor Diet**. Serotonin is made from **proteins, vitamins and minerals**
4. **Toxic substances.** Heavy metals, **pesticides**, drugs, damange nerves.
5. **Certain drugs and substances** such as caffeine, alcohol, nicotine, antidepressants (long term), and some cholesterol lowering medications
6. **Hormone changes** can cause low levels of serotonin/imbalances.
7. **Lack of sunlight** contributes to low serotonin levels

adapted from: IntegrativePsychiatry.net

Serotonin

You may have a shortage of serotonin if you have:

- a sad depressed mood
- low energy
- negative thoughts
- feel tense and irritable
- crave sweets or junk carbohydrates
- reduced interest in sex or other activities.

Stress → Low Serotonin → Many Symptoms → Stress

Other serotonin related disorders include:

•Depression
•Anxiety
•Panic Attacks
•Insomnia
•Irritable bowel
•PMS/ Hormone dysfunction
•Fibromyalgia
•Obesity
•Eating disorders
•Obsessions and Compulsions
•Muscle pain
•Chronic Pain
•Alcohol abuse
•Migraine Headaches

Serotonin is key to our feelings of happiness and very important for our emotions because it helps defend against both anxiety and depression and helps:

- How you feel about yourself, life and the world around you
- Problem solving through difficulties and challenges
- Building relationships and support
- Achieving goals in life

Serotonin = important key to happiness index

A "PRIMER" Resources

2) Family and Community Support—immediate and intergenerational families, and intertwined communities can be a source of both stress and strength—attend to self-help and other resources, and other people's needs as family and community support is a two way street.

3) Problem Solving Techniques—use processes to: define the problem/stress; consider pros and cons to alternatives; select a plan; take action steps; identify resources; and use group/family meetings. Be "proactive" in problem solving.

4) Goal Setting—Make them **SMART—S**pecific, **M**easureable, **A**chievable, **R**ealistic and **T**ime-Based.

Exercise—Release Endorphins and other neurotransmitters

The first thing you might think of when it comes to exercise and depression is what is commonly known as "runner's high." This describes the release of endorphins that your brain experiences when you **physically exert** yourself. Endorphins are a type of neurotransmitter, or chemical messenger. They help relieve pain and stress.

Physical activity also stimulates the release of dopamine, norepinephrine, and serotonin. These brain chemicals play an important part in regulating your mood. **Regular exercise can positively impact serotonin levels in your brain.** Raising your levels of serotonin boosts your mood and overall sense of well-being. It can also help improve your appetite and sleep cycles, which are often negatively affected by depression.

Regular exercise also helps balance your body's level of stress hormones, such as adrenaline. Adrenaline plays a crucial role in your fight-or-flight response, but too much of it can damage your health.

Adapted from Healthline

Too much adrenaline due to Chronic stress can fry/shorten nerve receptors.

Exercise!

Good Grief….We Just Lost…

1) **Farming** is a high risk occupation both in physical safety and financial security. The natural environment with weather, market forces and hard work can end in profit or loss.
2) **Loss** is a reality to farming in the event a cow dies, a crop is flooded or cash flow and finances even causes loss of the farm.
3) **Grief** is experienced as normal and can even be healthy as one reacts to the loss of something that is loved and cherished. Dealing with grief is a learned skill to help one understand grief, not to overcome it, but process through it to hopefully return to normal functioning over time.

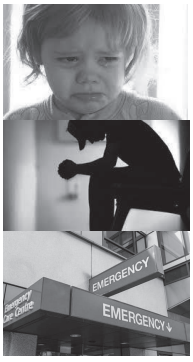
A "PRIMER" Resources

Resources are important in life. Families that are able to make positive meaning of their stressors and use effective coping strategies as well as internal and external resources are more likely to adapt as well (Xu, 2007). This applies to individuals, too! Internal resources and coping strategies are in other sections. External resource needs tend to focus on things that help develop skills in:

1) Interpersonal Communication—everyone has their own beliefs, feelings, needs and agenda to be shared. Knowing healthy/ideal versus unhealthy/common behaviors can separate success and failure in overcoming stress/conflict.

Good Grief….We Just Lost…

1) **Loss** is a life event where someone or something that is loved suddenly or slowly ceases to be a part of our lives.
2) Dealing with an **acute loss** (barn fire, death in family) or a chronic loss (loss of profits over time), or an **ambiguous loss** (not sure of the what, how and whys of a loss) all need the process of grief to deal with the loss.
3) Even though loss is typically bad, the "grief process" can be good in helping one deal with the loss and return to meaningful life in due time.



Deacon Larry's "Good Grief" recipe:

Grief is unique—everyone needs their own recipe
Grief takes time—let it work in due time
Grief has loss—keep the memories alive
Grief can cause anger—be aware in response
Grief is messy—let the mind and body cry
Grief is "extreme" stress—practice safety
Grief tastes bitter—recall the happy times
Grief can be lonely— others feel helpless
Grief stops one's world—the world moves on
Grief needs empathy—but accept the sympathy
Grief needs comfort—make healthy choices
Grief needs exercise—"move" your spirit into it
Grief needs hope—tend to feelings of despair
Grief needs a smile, at least once in a while! ☺

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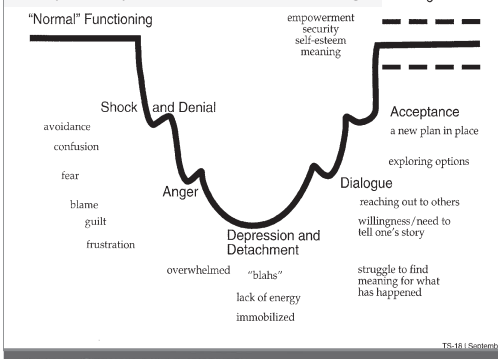
Understanding Loss

The magnitude and abruptness of the loss determines the amount of shock, denial, anger and anxiety that may occur and the associated feelings.



Feelings of being overwhelmed, depressed, immobilized with lack of energy, is an area of biggest concern as loss of hope may cause unhealthy decisions. ***Hopefully***, through the struggle and reaching out in dialogue to others, exploring options and life without, ***a new acceptance can be attained,*** with a return to a meaningful life—life just different than before.

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With grief, people often wonder--are YOU over it YET?
*With **"Good Grief"**, the goal is **NOT** to get over it, but to savor the memories of what was lost, and process through grief to return to a meaningful life in one's own time.*

*"Too often **we underestimate the power** of a touch, a smile, a kind word, a listening ear, an honest compliment, or the smallest act of caring, **all of which have the potential to turn a life around."*** -- *Leo Buscaglia*

Let "Good Grief" Build Stamina to Survive What We Didn't Think Possible— for "Good Grief's" Sake!
Deacon Larry Tranel, Bereavement Minister

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Good Grief….We Just Lost…

1) **Isolation** of many rural farm families is not a friend to the "Good Grief" **process—family and community support is often the best medicine**, research shows, even moreso than trained counselor—though may be important in the process, too.
2) Many sharp, **entangled emotions** go through the grieving person. When it is the loss of a dairy herd or farm, knowing this tradition is coming to an end, **can cause farmers to feel shame and failure**. An accident or loss of assets can cause farmers to feel guilt.
3) Males are engrained to protect and provide for their families and feel at fault even though external market forces, which farmers have no control over, are making it difficult for many others to survive in the same farm climate. Know one is not alone!

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A Farm Stress Resource Package

1. **Farm Market Reality, Stress and Grief**
2. **A "PRIMER" on Farm Stress Resiliency**
3. **Keys When "Married" to Farm Stress**
4. **From One Dairy Girl to the Next**
5. **Helping Farm Men Under Crisis!**
6. **Farm Youth Stress and Challenges**
7. **Good Grief, We Just Lost…!!!**

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Beyond Lysine and Methionine: What Have We Learned About Histidine?

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Introduction

Amino acids are the building blocks of protein synthesis. Of 20 amino acids usually taking part in protein synthesis, the body is able to produce only 10 in adequate quantities. Therefore, the other 10 amino acids (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) must be obtained in the diet and thus called essential amino acids. It is now a common knowledge that a deficiency of one or multiple essential amino acids would significantly limit milk protein synthesis in lactating dairy cows. Lysine and methionine are considered the most limiting amino acids for dairy cows in North America, as commonly used feeds such as corn and soybean are deficient in those two amino acids. Nonetheless, marked increases in prices of those conventional feeds in recent years have prompted many considerations about alternative feeds for dairy cows. In this context, partial replacement of corn with other cereal grains such as barley and wheat has been recognized as a promising strategy. Moreover, along with greater demand of forage inventory, nutrient management in dairy farms has promoted growing more and more cereal-grain cover crops such as rye, oats, wheat, triticale, and barley. Those crops uptake more nutrients from manure and better tolerate cold weather in winter and fall than corn. Nonetheless, cereal cover crop forages contain 20 to 30% greater rumen degradable protein than corn silage indicating an increased contribution of microbial protein to the amino acid supply for milk production. Bergen et al. (1968) demonstrated that rumen microbial proteins were deficient in histidine compared to the requirements of protein synthesis in the body. There have been several studies focused on the impact of supplementation of histidine in dairy cows fed grass silage and other cereal grain supplements. However, the conclusions particularly about the limitations of methionine and lysine were mixed. For instance, Vanhatalo et al. (1999) and Korhonen et al. (2000) concluded that histidine was the first limiting amino acid, while neither methionine nor lysine were the second limiting, when grass silage-based diets were supplemented with cereal grains. On the other hand, Kim et al. (2000) concluded that not only histidine but also methionine and lysine were limiting for milk protein production in cows consuming similar diets. We hypothesized that bringing those literature data into one place and conducting a global statistical analysis would help us more accurately understand the limitations of histidine relative to that of methionine and lysine in cows consuming other cereal forages and grains than corn. Therefore, we conducted a meta-analysis using data from controlled-studies where histidine was supplemented with or without methionine and lysine in lactating dairy cows fed grass silage and other cereal grain-based diets.

Materials & Methods

Twenty-five observations (treatment means) of dry matter intake, diet composition, milk yield and composition, and amino acid dose were obtained from seven studies (Choung et al., 1995; Vanhatalo et al., 1999; Kim et al, 2000; Korhonen et al., 2000; Kim et al., 2001; Huhtanen et al., 2002; Haque et al., 2012). These studies included abomasal or intravenous infusion of histidine relative to a control group (saline infusion). A summary of basic characteristics of the diet and cows are given in Table 1. All the studies except one (Haque et al. 2012) used silage made of perennial rye grass, timothy grass or meadow fescue grass as the only forage. Barley grain was the primary concentrate supplement in all the studies. The average sample size was four cows and ranged from two to six cows per treatment. The 25 observations altogether represented a population of 107 early- and mid-lactating multiparous Holstein (52%) and Ayrshire (48%) cows in Finland, United Kingdom, and France. The site of amino acid infusion was however confounded in breed as all the Holstein cows received amino acids via intravenous infusions, whereas all the Ayrshire cows received them via abomasal infusions.

Of 25 observations, 12 observations were related to infusion of histidine without methionine or lysine. Three of those histidine infusions also included leucine but they were still considered to include only histidine (**His**) as the effects of leucine were negligible. Six and seven observations were related to infusions of histidine with methionine and lysine (**His+ML**) and with methionine, lysine, and tryptophan (**His+ML+Trp**), respectively. Table 2 gives the dose of individual amino acids infused in each treatment group. Infusion of histidine alone or with other Infusion of histidine alone or with other amino acids did not change milk fat yield compared to that of control cows. Infusion of histidine alone however decreased milk fat content by 0.17 (P = 0.001). In line with milk yield increments, infusion of histidine alone increased milk lactose yield by 36.6 g/d (P < 0.001). The additions of tryptophan methionine, and lysine nullified that effect (P = 0.619). Infusion of histidine alone did not change milk lactose percentage (P = 0.244) but infusion of histidine with methionine and lysine or with methionine and lysine plus tryptophan reduced milk lactose percentage in additive manner (-0.06±0.03 and -0.26±0.05 percentage units, respectively).

The mean effects of His, His+ML, or His+ML+Trp on a given response (e.g., milk yield) was calculated in terms of mean difference (MD), which is the difference in the response variable between control and amino acid infusion treatment in each individual study.

MD=Mean response(control)-
Mean response (treatment)

The MD were then combined and summarized across all the studies using the metafor package in R software as described in Appuhamy et al. (2013). The present approach of meta-analysis accounts for the random variability of individual studies. A preliminary data analysis revealed that the site of infusion (or breed) had a significant impact on the production responses to amino acid infusions (Table 3). For instance, cows receiving intravenous infusions were related to a significantly greater milk yield increases than cows receiving abomasal infusions. Therefore, the effects of His, His+ML, and His+ML+Trp on each response of interest were adjusted for the variability in the site of infusion by including it in the statistical models.

Results

The mean changes in DMI, milk yield, and milk component yields for supplementation of His alone or with other amino acids are given in Table 4. Supplementation of histidine alone at a dose of 6.5 g/d increased DMI by 0.25 kg/d (P = 0.002). Addition of methionine and lysine or methionine and lysine plus tryptophan to histidine infusions did not significantly change that increment. When adjusted to the site of infusion, supplementation of histidine alone was related to a 0.94±0.16 kg/d increase in milk yield (P<0.001). Again, the additions of other amino acids did not change the milk yield increment. In line with the milk yield increase, protein yield increased by 35.0 g/d for the histidine supplementation (P < 0.001). Addition of methionine and lysine to histidine did not change the protein yield increment (P = 0.466) but addition of them with tryptophan tended to further increase the protein yield increment to 74.4 g/d (P = 0.069). Supplementation of histidine alone tended to increase milk protein content by 0.04 percentage units (P = 0.081) compared to the milk protein content of control cows (3.0%, Table 1). Addition of methionine, lysine, and tryptophan to histidine further increased milk protein content increment to 0.21 percentage units.

Conclusions

Regardless of the site of infusion (or breed), supplementation of histidine alone (6.5 g/d) increased DMI (0.25 kg/d), milk yield (0.94 kg/d), milk protein yield (35 g/d), milk protein content (0.04 percentage units) and milk lactose yield (37 g/d)), and decreased milk fat content (0.17 percentage units). Supplementation of histidine (6.5 g/d) with methionine (8.2 g/d) and lysine (16.1 g/d) did not affect those changes. However, addition of tryptophan into a mixture of histidine (6.5 g/d), methionine (7.3 g/d), and lysine (25.8 g/d) further improved milk protein yield and milk protein content by 74.4 g/d and 0.21 percentage units, respectively. Again, the real cause of those improvements were not clear, as the supplementation of tryptophan was confounded in different lysine: methionine ratios. Overall, this meta-analysis supports previous observation that histidine is significantly limiting for milk protein production in dairy cows consuming grass silage and cereal grain-based diets. Moreover, it is likely that a tryptophan deficiency or an improper ratio of lysine and methionine could also be limiting for milk protein production in those cows.

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Table 1. A summary of the data

Variable	Mean	Minimum	Maximum
----------Diet----------			
DMI, kg/d	17.0	13.6	19.9
NE_L, Mcal/d	26.0	21.6	32.7
Grass silage, % of DM	58.2	0.0*	74.6
Barley grain, % of DM	17.1	4.8	23.3
Crude Protein, % of DM	16.8	12.9	20
NDF, % of DM	41.6	27.4	47.9
----------Animals----------			
BW, kg	551	509	621
DIM	82	35	179
Milk yield, kg/d	23.8	14.2	32.7
Milk protein, %	3.0	2.7	3.7
Milk fat, %	4.3	3.3	5.9
Lactose, %	4.8	4.3	5.0

Table 2. Mean dose of amino acids (g/d) in each infusion treatment

Infusion	Histidine	Methionine	Lysine	Tryptophan	Lysine: methionine ratio
His	6.5	0	0	0	NA
His+ML	6.5	8.2	16.1	0	1.96
His+ML+Trp	7.2	7.3	25.8	3.3	3.53

Table 3. Mean changes in DMI and production performance of cows having abomasal or intravenous infusions compared to control cows

Response	Abomasal	Intravenous	SEM	*P*-value
DMI, kg/d	0.20	0.28	0.09	0.583
Milk yield, kg/d	0.90	1.90	0.08	<0.001
Milk protein yield, g/d	37.8	61.0	10.3	<0.001
Milk fat yield, g/d	-7.90	19.0	11.6	0.096
Milk lactose yield, g/d	33.8	84.5	11.9	0.003

Table 4. Mean (±Standard error) changes in DMI and production performances of lactating dairy cows for infusion of histidine alone (+His), histidine plus methionine and lysine (His+ML), and histidine plus methionine, lysine, and tryptophan (His+ML+Trp), when adjusted for the site of infusion

Variable	Infusion Treatment		
	His (n = 12)	His+ML (n = 6)	His+ML+Trp (n = 7)
DMI, kg/d	0.25±0.08	0.18±0.06	0.29±0.18
Milk yield, kg/d	0.94±0.16	0.90±0.11	0.64±0.36
Milk protein			
Yield, g/d	35.0±7.9	41.8±9.6	74.4±22.7
%	0.04±0.02	0.06±0.03	0.21±0.09
Milk fat			
Yield, g/d	-5.1±10.7	-4.5±15.7	-34.7±28.7
%	-0.17±0.05	-0.03±0.09	-0.21±0.16
Milk lactose			
Yield, g/d	36.6±10.2	27.9±12.2	-13.8±27.7
%	-0.02±0.02	-0.06±0.03	-0.26±0.05

Rearing Calves for Maximum Production and Health

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Introduction

Improving performance and profits of dairy enterprises focuses typically on feeding and managing the lactating herd. However, this approach often results in a less-than-desirable attention to decisions pertaining to calves and heifers. This less-than-desirable attention to calves and heifers is likely to be one the most important reasons behind the astonishing failure rate of the new products of the dairy industry (i.e. heifers after first calving). Several studies report that between 9 and 17% of the heifers that reach first calving do not finish the first lactation (Bach, 2011; Sherwin et al., 2016). This figure is due to many aspects, but basically, it is related to a combination of inadequate nutrition and rearing practices coupled with lack of sufficient on-farm information to properly manage young stock. Contrarily to the situation in lactating cows, where management is based on records of milk yield, milk composition, feed intake, body condition, etc..., the most common situation in heifer rearing is that management is based on "feeling" rather than being based on methodic data collection and record keeping. This article will review several nutritional aspects aimed at improving performance of calves through nutrition and management with special emphasis on potential long-term effects on productivity and health.

Economic Consequences of Calf Rearing

Raising dairy replacements properly may represent important economic savings and lead to a reduced environmental impact of the dairy enterprise.As an example, a dairy herd milking 100 cows, can generate an anual net-profit of ~10,000 $US just by reducing age at first carving (AFC) from 28 to 24 months. Generating the same economic profit through improvements in milk production, with 100 cows, would require to increase average daily milk yield by at least 6-7 kg per cow and day. Both target (decrease AFC or increase milk production) are doable, but the first one is much easier and plausible to attain that the latter; however, in many instances producers and consultants strive to increase a couple of liters milk yield whereas much greater profits could be gathered by decreasing AFC. Nevertheless, not only age is important, it is also crucial to ensure that heifers calve with an adequate body weight (BW). Evidence from the literature (Hoffman and Funk, 1992; Bach and Ahedo, 2008) suggest that age at first calving has little correlation with milk production during the first lactation provided AFC is above 22 months, and BW seems to have a larger effect on milk production than age. Bach and Ahedo (2008) showed that for every 70 kg of BW at calving, an increase of 1,000 kg of milk yield during the first 305 d of the first lactation could be, on average, expected. Therefore, a reasonable target for raising dairy heifers under intensive conditions would be achieving a first calving between 22 and 24 months with a BW about 650 kg, or assuming an 11% loss in BW after parturition, a BW after calving of about 580 kg.

Thus, the question becomes what is the best growth curve to achieve 650 BW at 22 months. Most producers believe that the most expensive rearing period of calves is between birth and weaning (due to high feed costs and labor intensive procedures). This is partly true: the cost of each kilogram of feed (either starter concentrate or milk replacer) is, in many occasions, the greatest among the feeds in a farm. However, this does not directly imply that the return on the investment associated with pre-weaned calves are the greatest. The goal when rearing calves is to achieve 650 kg at 22 months of age, thus, calves need to put about 540 kg (580 kg of final BW minus 40 kg of BW at birth) of true BW (not accounting for the placenta and the baby calf they will carry during the last 9 months). Ironically, and despite that the unit cost of starter feed and milk replacer (MR) are high, every kilogram of BW achieved during the first 2 months of life is less expensive that a kilogram deposited when the heifer is 18 to 20 months of age. The reason for this is that feed efficiency (the proportion of feed that is converted into BW) is greatest (about 60%) during the first 2 months and lowest during the last months of pregnancy (about 7%). Thus, the high efficiency of conversion of MR and starter feeds offsets their high costs, and growing fast during the 2 months is more economically advantageous than postponing the deposition of these kilograms during the last phase of the rearing period (despite unitary feed cost are fairly low at that

stage). More important, the most economically efficient growth during the rearing process occurs after weaning, when calves can utilize solid feed (relatively inexpensive at that age) with feed efficiencies around 30% (Bach et al., 2017b).

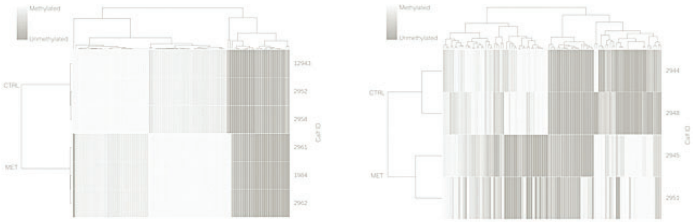
Performance at Adulthood as Affected by Plane of Nutrition Early in Life

Before birth

It is well established that nutrition represents one of the greatest environmental determinants of an individual's health and metabolic activity, and that it is likely that today's cow, with high milk yield but also reproductive and metabolic challenges, is not only a consequence of genetic selection, but also the result of the way her dam was fed and the way she was fed early after birth (Bach, 2012). However, the mechanisms involved in orchestrating the interaction between nutrition and genetic and epigenetic modifications is fairly unknown, and thus the potential long-term effects of nutrition through modifications of gene expression are often overlooked.

Figure 1. Cluster analysis of CpG sites differentially methylated (P < 0.01) in the offspring born to lactating (A) dams or heifers (B) that received a supplementation of methyl donors or a placebo during early pregnancy. Control lactating dams received a placebo, whereas MET dams received weekly administrations of 200 mg of folic acid and 20 mg of vitamin B12. Control heifers received a placebo, whereas MET dams received weekly administrations of 100 mg of folic acid and 10 mg of vitamin B12. (Adapted from Bach et al., 2017a)

A) B)



There is evidence that providing high planes of nutrition in calves results in positive long-term effects on production (Bach, 2012; Soberon et al, 2012; Gelsinger et al., 2016). Furthermore, two prospective studies indicated that growth rate early in life is positively correlated with survivability to second lactation (Bach, 2011; Heinrichs and Heinrichs, 2011). However, whether these changes are due to epigenetic modifications is currently unknown. It is likely that supplementation of methyl donors during pregnancy may have an influence in the regulating epigenetic marks. Some recent evidence (Bach et al., 2017a) shows that supplementation of methyl donors (i.e., vitamin B12 and folic acid) during pregnancy has an effect of the epigenome of the offspring, and the changes in methylation pattern of the offspring differs between daughters born to heifers compared with daughters born to lactating cows (Figure 1). However, we do not yet know whether these changes exert a positive or negative influence in performance at adulthood. Jacometo et al. (2016) reported that supplementing lactating dams with methionine (a methyl-donor) resulted in calves that underwent a faster maturation of gluconeogenesis and fatty acid oxidation in the liver, which would be advantageous for adapting to the metabolic demands of extra-uterine life. On the other hand, the long-term effects associated with greater planes of nutrition could also be mediated by non-epigenetic changes. For instance, feeding a MR rich in linolenic acid (1.5% of the total DM) compared with a regular MR (providing 0.45% of linolenic acid) modified the expression of hepatic genes, including genes predicted to decrease infections and to increase lipid utilization and protein synthesis (Garcia et al., 2016). However, whether these changes were just a result of differences in metabolic pathways or a consequence of epigenetic changes (which would then have a sustained response) was not determined in that study, but it is likely that the observed effects were a result of both, metabolic activity and some changes in the epigenome. Geifer et al. (2017) hypothesized that increased planes of nutrition during the pre-weaning period enhances the responsiveness of the mammary tissue to mammogenic stimulus as they reported an increase in the expression of estrogen receptors in the mammary gland of animals fed increased planes of nutrition compared with traditionally-fed calves.

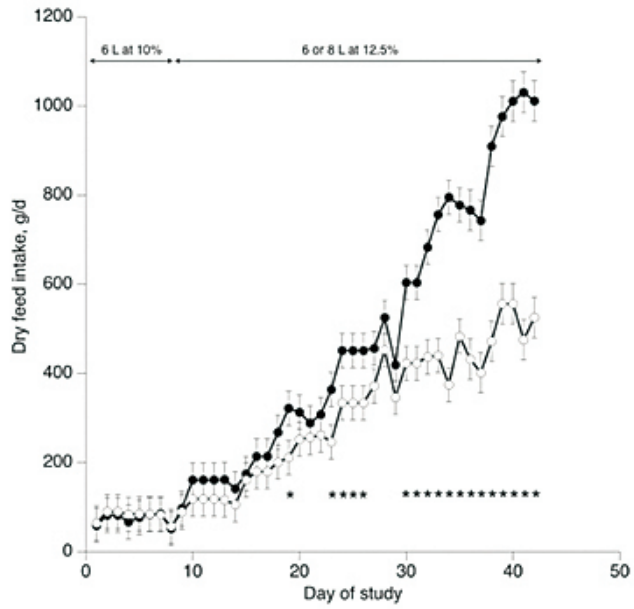
Liquid Feeding

Right after birth, we must ensure that the newborn calf receives an adequate amount of antibodies and nutrients to avoid illness during the early stages of life. Most emphasis in colostrum has been placed on immunity and we have often forgotten that colostrum provides a large amount of nutrients (mainly protein and fat). Calves, only receive colostrum 2 or 3 times and then they are moved to whole milk or MR with a substantial reduction in nutrient supply. To partially compensate for this difference, some producers are increasing the DM of MR by using dilution rates of 15% rather than the traditional 12.5% (similar to the solid contents of milk). However, the relative proportion of nutrients offered in MR still differs quite drastically from that found in whole milk, and there is some controversy about the optimal relative proportion of nutrients in MR. For instance, Hill et al. (2006) concluded optimal concentration of protein and fat in MR should be approximately 26% CP and 17% fat, which was later corroborated by Hill et al.

(2009b) who reported a linear decrease in average daily gain (ADG) as the CP of MR decreased from 27 to 25 and 23% while maintaining fat content fixed at 17%. Daniels et al. (2009) reported no differences in growth rate between 5 and 9 weeks of calves offered 950 g/d of a MR containing either 28% CP and 20% fat of 28% CP and 25% fat although calves offered the 27:28 MR tended to grow more between weeks 5 and 7 than those fed the 28:20 MR. Similarly, Morrison et al. (2009) compared one MR providing 21% CP and 18% with one providing 27% CP and 17% fat and reported no difference in ADG between calves fed either 5 or 10 l/d of each MR, and Hill et al. (2009a) reported no differences between calves fed a MR containing 27% CP and 20% fat or 27% CP and 17% fat. A potential reason for the lack of response to increased fat or protein supply through the MR could be, in part (other reasons could include inadequate amino acid or fatty acid profile, poor digestibility of the ingredients used), changes in solid feed intake, but, Hill et al. (2009a) reported that calves fed a MR containing 27% CP and 31% fat achieved equivalent solid feed intakes than calves consuming a MR containing 27% CP and 17% fat, but surprisingly, calves fed the high-fat MR had a lower ADG compared with those fed the one containing 17% fat. In a former study, Hill et al. (2007) had already reported that adding energy in MR via lactose or CP, but not via fat, improved ADG. However, offering MR with about 27% MR and about 17% fat results in an oversupply of lactose (>45%). Lactose, differently from fat, is vigorously fermented by intestinal bacteria and may represent a risk for diarrhea.

Based on economic arguments and empirical evidence of increased longevity and productivity associated with improved growth rates early in life, the industry is now providing larger amounts nutrients to sustain rapid growth rates (>850 g/d) during the first 2 months by mainly offering larger volumes of milk or MR. An "ideal" feeding program for calves could probably consist on feeding 6 l/d at 15% (900 g/d of solids) along with a highly palatable starter feed and some chopped high-fiber forage (see below). Offering 8 l/d may foster increased growth rates early in life but is likely to compromise intake of starter (Bach et al., 2013b; Figure 2) and if fed twice daily may foster insulin resistance in calves (Bach et al., 2013a). Nevertheless, concerns about incurring in long-lasting detrimental effects due to insulin resistance seem unlikely as Yunta et al. (2015) showed that after 20 d after weaning there were no differences in insulin sensitivity among calves fed 4, 6, o 8 L/d of MR during the first 2 months of life.

Figure 2. Dry feed intake during the first 42 d of the study as affected by the level of milk replacer (MR). Open circles denote 8 L of MR/d and solid circles depict 6 L of MR/d. Asterisks indicate days of study when dry feed consumption differed (P < 0.05) between MR allowances. Adapted from Bach et al. (2013b).



Solid Feeding

Some schools of thought have proposed that the positive effects on future milk production observed when providing high planes of nutrition early life could only be achieved by providing increased amounts of MR (Soberon et al., 2012). However, Bach et al. (2012) and more recently (Gelsinger et al., 2016) have described that nutrients supplied from liquid or solid feeding are equally effective in inducing positive long-term effects in milk production. Thus, fostering solid feed intake should be a pivotal objective for any rearing program mainly because 1) it will help in improving nutrient supply and growth, 2) will contribute to increase milk production in the future, 3) will enhance rumen development, and 4) will facilitate the weaning process. Calves fed high milk allowances tend to struggle during transition onto solid feed, and part of the growth advantage achieved before weaning may be lost due to (1) diminished consumption of nutrients, and (2) reduced digestibility. Early dry feed consumption fosters early rumen microbial development, resulting in a greater rumen metabolic activity (Anderson et al., 1987). Thus, the high level of MR in calves following an enhanced growth feeding program, may delay the start of dry feed consumption, and consequently, it may delay rumen development making it difficult to wean calves and maintain rapid growth rates. This may have important economic consequences (in addition to some potential health

issues). Average daily gain right after weaning is the most profitable one during the entire rearing period of a heifer, and in addition, ADG during the late phase of weaning transition (between 160 and 230 d of age) is positively correlated with future milk production (Bach and Ahedo, 2008).

There are several strategies to improve starter feed intake and supporting greater ADG early in life. One strategy consists of including 'palatable' ingredients in the formulation of the starter. Miller-Cushon et al. (2014) evaluated the palatability of several energy and protein ingredients concluded that corn gluten feed and corn gluten meal should be avoided, and wheat, sorghum, corn, soybean meal should be prioritized to increase palatability of starters. Oats, which are commonly included in starters, were found to have low palatability, and thus their inclusion in formulation of starter should not be forced, and if possible it should be avoided. In terms of nutrients, a good starter should contain 18% CP and 3.2 Mcal/kg of metabolizable energy, although starters containing 20% or more CP may have some benefits right after weaning when rearing calves in intensified milk regimes to provide sufficient metabolizable protein and ensure amino acids do not limit growth. In fact, Stamey et al. (2012) reported increased solid feed intake around weaning (with ~300 g difference in DM intake at weaning) when comparing calves fed ~900 g/d of solids from a MR with 28.5% CP and 15% fat and a starter feed containing 25.5% CP compared with one containing 20% CP. However, when offering restricted amounts of milk, feeding starter feeds with >22% CP (DM basis) provides no additional advantage in growth (Akayezu et al., 1994). Thus, it seems that with large milk allowances, calves may benefit from increased CP supply via starter feed. Lastly, it may seem logical to limit starch content to avoid acidosis, but the calf actually needs starch, not only for rumen development (as its fermentation will generate large amounts of volatile fatty acids that stimulate papillae growth), but also to provide energy to sustain growth. Thus, inclusion of low levels of starch in starter feeds is not recommended. In general, feeding starter feeds containing between 30 and 35% starch should be adequate (Bach et al., 2017b).

Several studies (Khan et al. 2011; Castells et al., 201; Castells et al., 2013; Montoro et al., 2013) have shown that an effective method to foster solid feed intake of calves, contrary to what it has been traditionally recommended, is to provide ad libitum access to poor quality (nutritionally) chopped straw or chopped grass hay. In the last century, it was believed that feeding a fiber source to young dairy calves was necessary because it improved rumen health and that if no forage was provided to calves, low fiber content of the complete starter should be avoided (Jahn et al., 1970; Thomas and Hinks, 1982). But, later, in the 70's the concept of textured starter was introduced (Warner et al., 1973). It was then assumed that with textured starters no additional feeding of forage was needed. However, several authors (Kincaid, 1980; Thomas and Hinks, 1992; Phillips 2004; Suárez et al., 2007; Castells et al., 2012) have reported either an increase in starter intake or no effect on total feed consumption with the inclusion of dietary forage. Castells et al. (2012) offered an 18% NDF and 19.5% CP pelleted starter in conjunction with different sources of chopped forage to young dairy calves, and reported that feeding chopped grass hay or straw improved total dry feed intake and rate of growth, without impairing nutrient digestibility and gain to feed ratio. In contrast, when the forage was alfalfa hay, these benefits were not observed. Several studies (Hill et al., 2008) have argued that feeding forage (hay and straw) to pre-weaned dairy heifers reduces starter and overall dry matter consumption. It is important to note that, in the studies by Castells et al. (2012, 2013), when calves were fed ad libitum chopped alfalfa hay, forage intake was 14% of total solid feed intake, whereas when calves were offered chopped oats hay, forage consumption did not surpass 4% of total solid feed intake. Nevertheless, some nutrition consultants do not advocate for forage feeding and propose feeding texturized starter feeds, but their success will depend on 1) the scraping ability of the starter feed, and 2) the amount of solid feed consumed by the calf. If calves consume large amounts of starter feed, even a texturized starter feed may fail providing sufficient scraping activity in the rumen. Thus, from a practical point of view and to remove uncertainty, feeding high-fiber (>60 %NDF) chopped forage along with a starter feed is likely to result inadequate growing performance. Lastly, an important consideration regarding feeding chopped forage to calves, is that it needs to be well and consistently chopped at about 2.5 cm in length and despite the fact that it must be high in fiber (>60%NDF) it must be of high quality (i.e., free of molds, mycotoxins and other impurities).

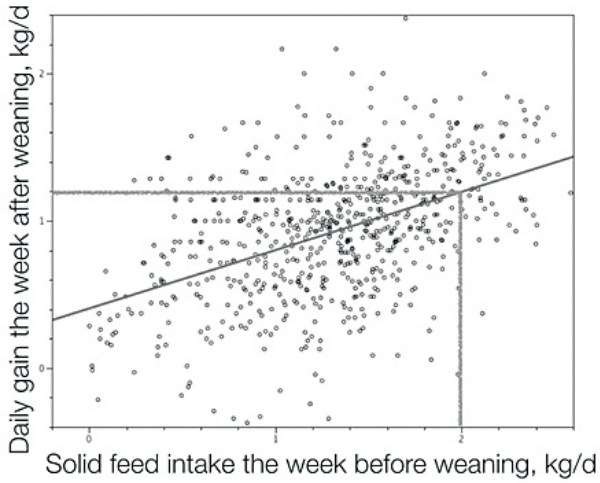
Weaning Calves

With the introduction of enhanced feeding programs, which consist of feeding large volumes of milk or even providing milk ad libitum, calves depend less on starter feed intake to meet their nutrient needs, and solid feed intake generally represents about <60% of total feed intake the week preceding weaning. In other words, with some enhanced feeding programs, calves are weaned with solid feed intakes around 500 g/d (Terré et al., 2007), which makes it impossible for the calf to maintain adequate ADG during the first weeks of transition. This growth slump has 3

main consequences: 1) potential reduction of milking performance at adulthood; 2) increased risk for disease, especially bovine respiratory disease (**BRD**); and 3) economic loss. Heinrichs and Heinrichs (2011) reported that milk yield during first lactation was positively correlated with the amount of solid feed consumed by calves at weaning (among other factors), and Ollivett et al. (2012) reported that fecal scores improved faster among calves challenged with Cryptosporidium parvum and receiving a high plane of nutrition compared with calves on a low plane of nutrition. Lastly, given that feed efficiency and growth potential are high and feed cost is relatively low during the transition, this represents the most profitable period to foster BW accretion and development. The aim should be achieving an ADG in the week following weaning greater >1.2 kg/d, and thus calves should not be weaned until they are consuming at least 2.0 kg/d of starter feed (Figure 3).

Lastly, an important aspect of weaning calves is the way they are socialized. Dairy calves have traditionally been reared individually, with the main purpose of stemming the spread of disease, a growing body of literature suggests several benefits of social housing in which two or more calves are housed together. Social housing allows for normal social development of the calf, and calves reared in groups respond to novel social situations with less fear and reactivity (de Paula Vieira et al., 2012). Social housing has been shown to encourage a greater solid feed meal frequency and intake before and during weaning (Bach et al., 2010; de Paula Vieira et al., 2010), may support greater ADG and reduce stress (de Paula Vieira et al., 2010) through weaning, and might reduce the severity of BRD (Bach et al., 2010). Similarly, grouping calves either at weaning time or during preweaning (Bach et al., 2010), when milk offer is reduced, can result in increased feed intakes and performance. Similarly, social housing at 1 week of age has been reported (Costa et al., 2015) to support greater intake and growth compared with calves grouped at 6 weeks of age; other studies also report similar results when providing social contact to calves before 3 weeks of age when feeding relatively large amounts (~1.0 kg/d) of milk (Jensen et al., 2015).

Figure 3. Relationship between solid feed intake the week preceding weaning and average daily gain the week after weaning (Adapted from Bach et al., 2017b).



Summary

Rearing costs represent a large investment for dairy producers. Implementing adequate rearing programs not only should result in optimal rearing cost but it should also ensure maximum return on the investment through improved productivity and longevity.

There exists substantial evidence that generous growth during the first 2 months of life results in improved milk performance at adulthood, and ironically, calves that grow faster early in life are commonly less expensive at first calving than those that grow more slowly.

This rapid growth can be achieved by providing about ~1 kg of milk powder per day along with a highly palatable pelleted starter feed fed next to free access to a chopped (~2.5 cm) high-fiber (>60% NDF) grass hay or straw.

Fostering growth right after weaning is highly desirable to lower rearing costs. For this reason, the weaning program must avoid the common growth slump that occurs when feeding generous amounts of milk. Thus, calves should no be weaned until they consume at least 2 kg/d of starter feed. Also, calves benefit from being weaned in groups rather than in individual hutches, and this should be moved into group housing as early as possible (ideally around 21 d at the latest).

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Management Strategies in an Era of High Pregnancy Rates

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Management Strategies in an Era of High Pregnancy Rates

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Professor of Dairy Science

DEPARTMENT OF
DAIRY SCIENCE
University of Wisconsin-Madison

Outline

- **A Reproduction Revolution**
- **The High Fertility Cycle**
- **New Repro Strategies**

TARDIS

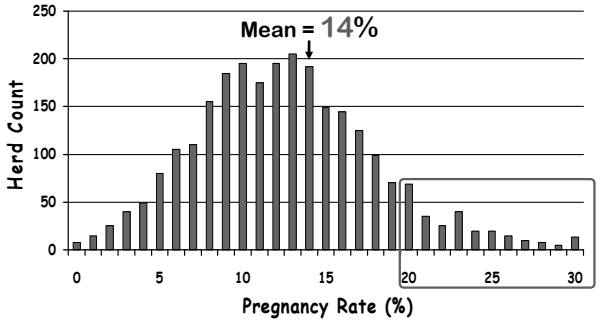
Time
And
Relative
Dimension
In
Space

1998

21-Day Pregnancy Rate - 1998

Minnesota DHI Data

Rapnicki P, Stewart S, Eicker S. 2001. Proc 4-State Appl Nutr Mgt Conf, La Crosse, WI



BREDSUM 21-Day Preg Risk

April, 2004 to April, 2005

Date	Br Elig	Bred	Pct	Pg Elig	Preg	Pct	Aborts
4/29/04	51	28	55	51	9	18	0
5/20/04	61	30	49	61	9	15	2
6/10/04	64	41	64	63	15	24	4
7/01/04	63	32	51	61	11	18	0
7/22/04	65	36	55	64	9	14	0
8/12/04	79	41	52	78	17	22	1
9/02/04	80	44	55	79	13	16	3
9/23/04	83	40	48	82	12	15	3
10/14/04	89	54	61	89	15	17	4
11/04/04	85	47	55	84	15	18	4
11/25/04	75	43	57	72	11	15	1
12/16/04	79	43	54	79	13	16	1
1/06/05	77	42	55	76	11	14	1
1/27/05	86	45	52	84	13	15	1
2/17/05	86	48	56	86	17	20	0
3/10/05	97	48	49	96	12	12	0
3/31/05	102	49	48	0	0	0	0
4/21/05	78	62	79	0	0	0	0
Total	1220	662	54	1205	202	17	25

Wait Period 50

BREDSUM By Times Bred

April, 2004 to April, 2005

	95% CI	%Conc	#Preg	#Open	Other	Abort	Total	%Tot	SPC
1	38-50	44	121	154	14	16	289	36	2.3
2	25-39	31	49	107	8	5	164	20	3.2
3	21-38	29	30	74	3	4	107	13	3.5
4	16-34	24	18	58	3	5	79	10	4.2
5	18-42	28	15	38	2	3	55	7	3.5
6	6-27	13	5	34	1	0	40	5	7.8
7	14-44	27	8	22	0	1	30	4	3.8
8	-	33	6	12	2	1	20	2	3.0
OTHERS	-	31	5	11	3	0	19	2	3.2
TOTALS	30-37	34	257	510	36	35	803	100	3.0

91% pregnant after 6 AI

J. Dairy Sci. 95:4683–4698
http://dx.doi.org/10.3168/jds.2011-5214

A simple formulation and solution to the replacement problem: A practical tool to assess the economic cow value, the value of a new pregnancy, and the cost of a pregnancy loss

V. E. Cabrera[1]
Department of Dairy Science, University of Wisconsin, Madison 53706

Dairy Replacement Calculator

Number of adult cows	1,000
Current herd turnover ratio	40%
Current adult herd 21-d pregnancy rate	14%
Current heifer conception rate at 1st service	60%
Average service rate for heifers	75%
Average service rate for cows	60%
Stillbirth + calf mortality	7%

	Year	net
Heifer calves required	564	
Heifer calves produced	401	-163
Springing heifers required	468	
Springing heifers produced	333	-135

14% Pregnancy Rate Scenario

- Adult cows = 1,000
- 21-day Pregnancy Rate = 14%
- Set culling rate to 40%

Springing heifers required = 468

Springing heifers produced = 333

Difference = -135

Old Problem - Insufficient Heifers

When you cannot generate enough of your own pregnancies, you have to buy pregnancies

Cost of a springing heifer > $2,000

Buying an extra 135 heifers per year results in $324,000 per year for a 1,000 cow dairy

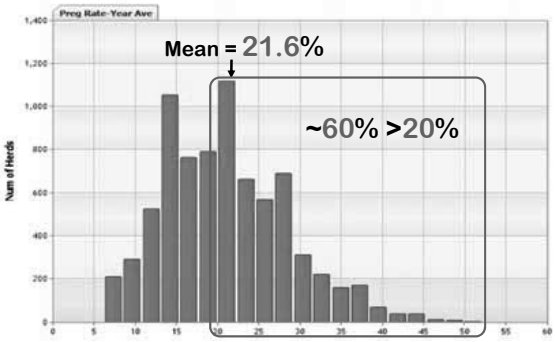
TARDIS

Time
And
Relative
Dimension
In
Space

2019

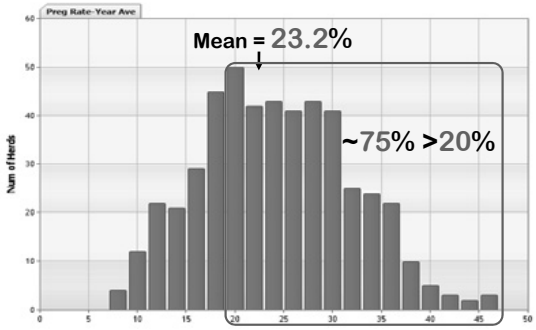
U.S. 21-day Pregnancy Rate - 2019

7,051 DRMS herds; 1,798,000 Holstein cows



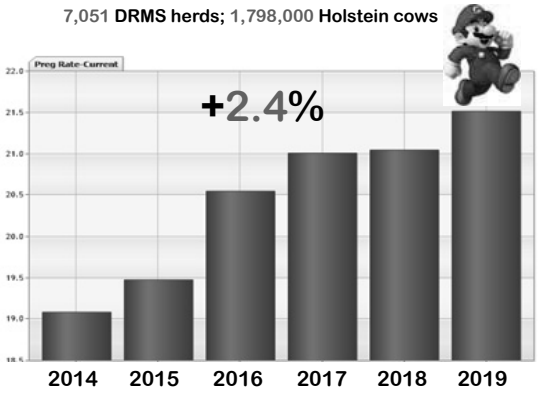
WI 21-day Pregnancy Rate - 2019

464 DRMS herds; 183,000 Holstein cows



US 21-day Pregnancy Rate Change

7,051 DRMS herds; 1,798,000 Holstein cows



BREDSUM By Times Bred

January, 2016 to January, 2017

	95% CI	%Cows	#Preg	#Open	Other	Abort	Total	#Tot	AIC
1	46-55	50	260	266	5	35	540	49	1.0
2	47-58	53	153	137	4	13	294	27	1.9
3	42-56	50	75	75	1	6	151	14	2.0
4	34-47	44	31	37	1	2	69	6	2.2
5	21-34	34	10	18	0	1	28	3	2.8
6	-	42	10	6	0	0	16	1	1.0
7	-	50	1	1	0	0	2	0	2.0
8	-	100	1	0	0	0	1	0	1.0
TOTALS	47-53	50	550	548	11	57	1101	106	1.8

90% pregnant after 3 AI

30% Pregnancy Rate Scenario

Adult cows = 1,000

21-day Pregnancy Rate = 30%

Springing heifers required = 437

Springing heifers produced = 437

Difference = 0

Culling rate at breakeven = 56%

30% Pregnancy Rate Scenario

Adult cows = 1,000

21-day Pregnancy Rate = 30%

Set culling rate to 40%

Springing heifers required = 353

Springing heifers produced = 453

Difference = +100

New Problem – Too Many Heifers!

Rearing costs from birth to calving = $2,100

UW-Extension 2015 Dairy Replacement ICPA Survey

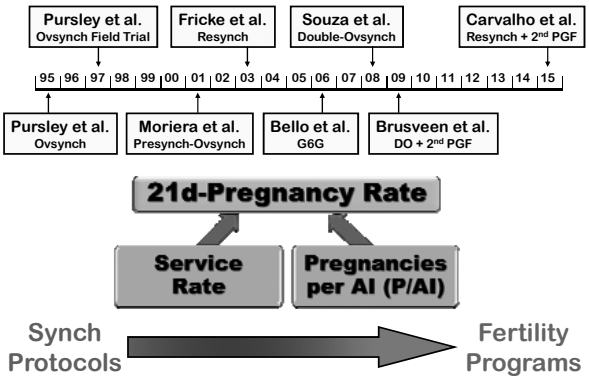
Top grade springing heifers = $800

Stratford, WI – March 11, 2019

Cost of each extra heifer = $1,300

Raising an extra 100 heifers per year results in $130,000 per year in excess rearing costs for a 1,000 cow dairy

1995 to 2015

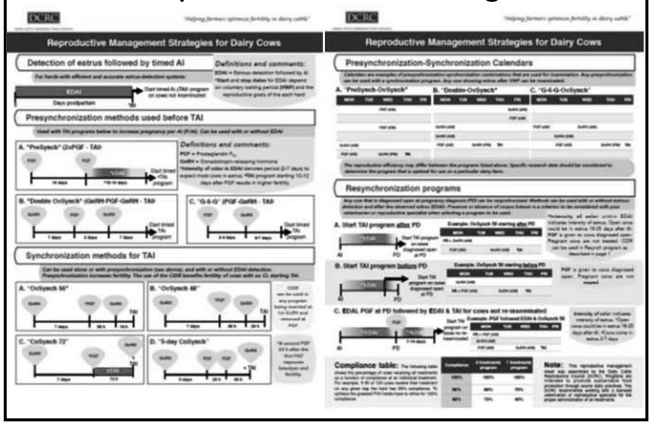


DCRC

DAIRY CATTLE REPRODUCTION COUNCIL

http://www.dcrcouncil.org/

http://www.dcrcouncil.org/



DCRC

DAIRY CATTLE REPRODUCTION COUNCIL

2017 DCRC Awards

Award	100% TAI	100% EDAI	EDAI/TAI +EDAI +Resynch	100% TAI 1st AI + EDAI + Resynch
Platinum	0	0	2	4
Gold	0	0	4	2
Silver	0	0	3	3
Bronze	0	0	4	2
Total	0	0	13	11

Pregnancy rate for the DCRC Platinum award winners from ranged 30% to 47%

J. Dairy Sci. 100:8507–8517
https://doi.org/10.3168/jds.2017-13210

Fertility of lactating Holstein cows submitted to a Double-Ovsynch protocol and timed artificial insemination versus artificial insemination after synchronization of estrus at a similar day in milk range

V. G. Santos,* P. D. Carvalho,* C. Maia,† B. Carneiro,† A. Valenza,‡ and P. M. Fricke*[1]
*Department of Dairy Science, University of Wisconsin, Madison 53706
†Diessen Serviços Veterinários Lda, 7001 Évora, Portugal
‡Ceva Santé Animale, 10 Avenue de la Ballastiere, 33500 Libourne, France

SR=100%

Double-Ovsynch

GnRH 7 d PGF 3 d GnRH 7 d GnRH 7 d PGF 24 h PGF 32 h GnRH 16h TAI

49%
n=294

Estrus

GnRH 7 d PGF 14 d Estrus detection + AI PGF 24 h PGF 7 d

39%
n=284

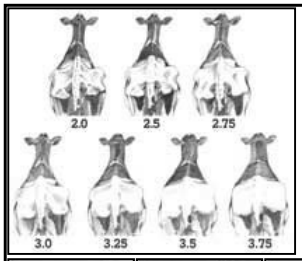
50±3 72±3 74±3 77±3 81±3

% pregnant cows at 110 DIM: 49 vs. 30

SR=78%

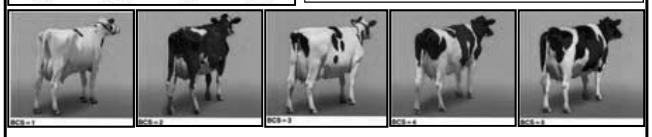
Outline

- A Reproduction Revolution
- The High Fertility Cycle



Body Condition Scoring

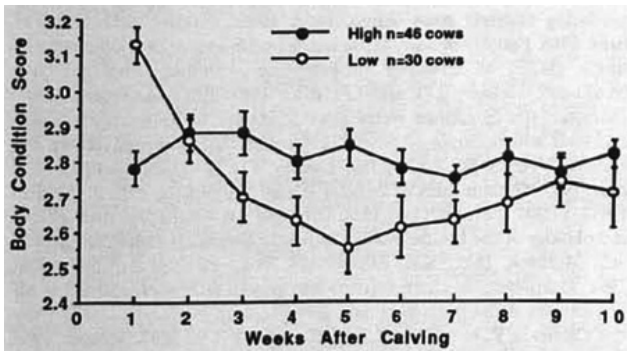
- BCS is a noninvasive method for estimating fat stores in live cows.
- Define: Ratio between amount of fat to the amount of nonfat matter (water, protein, ash) in the body of a living animal.
- Body condition change is an easy way to assess energy balance on farms.



1 2 3 4 5

Emaciated Thin Average Fat Obese

Britt, 1992



Britt, 1992

	High cows	Low Cows	P-value
n	46	30	
Milk yield (Kg)			
Average first 10 weeks	26	27	
Average yield for 305 d	8,155	8,272	
Conception rate (%)			
First service	62	25	<0.05
All services	61	42	<0.05

Three Studies:

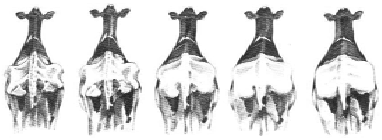
Relationships among changes in body condition score (BCS) and reproduction in lactating dairy cows

- **Carvalho et al., 2014**
  J. Dairy Sci. 97:3666-3683
- **Barletta et al., 2017**
  Theriogenology 104:30-36
- **Middleton et al., 2019**
  J. Dairy Sci. 102:5577-5587

J. Dairy Sci. 97:3666–3683
http://dx.doi.org/10.3168/jds.2013-7809

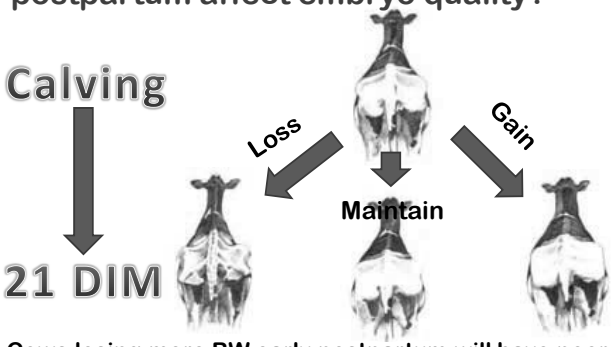
Relationships between fertility and postpartum changes in body condition and body weight in lactating dairy cows

P. D. Carvalho,* A. H. Souza,*[1] M. C. Amundson,* K. S. Hackbart,* M. J. Fuenzalida,* M. M. Herlihy,* H. Ayres,* A. R. Dresch,* L. M. Vieira,* J. N. Guenther,* R. R. Grummer,† P. M. Fricke,* R. D. Shaver,* and M. C. Wiltbank*[2]
*Department of Dairy Science, University of Wisconsin-Madison, Madison 53706
†Balchem Corporation, New Hampton, NY 10958



DEPARTMENT OF
DAIRY SCIENCE
University of Wisconsin-Madison

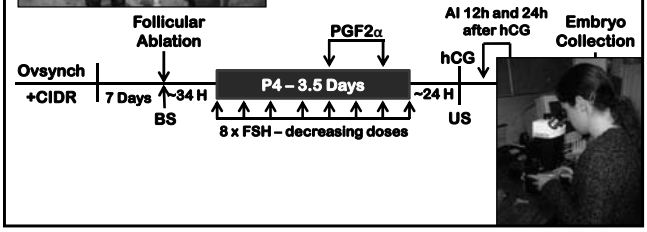
Does Body Weight change early postpartum affect embryo quality?



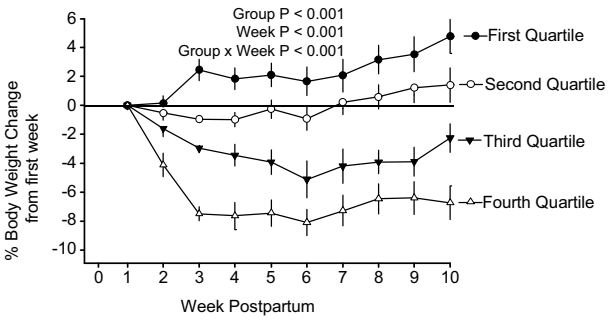
Cows losing more BW early postpartum will have poor embryo quality

Materials & Methods

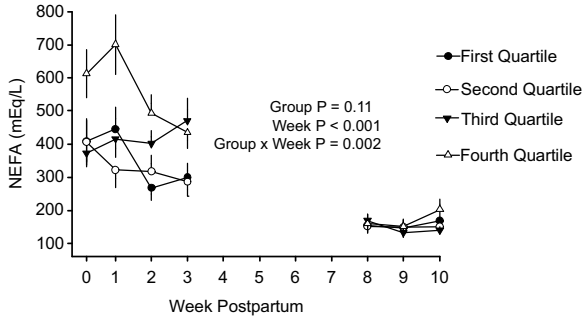
y cows f
nd supers



% Body weight change



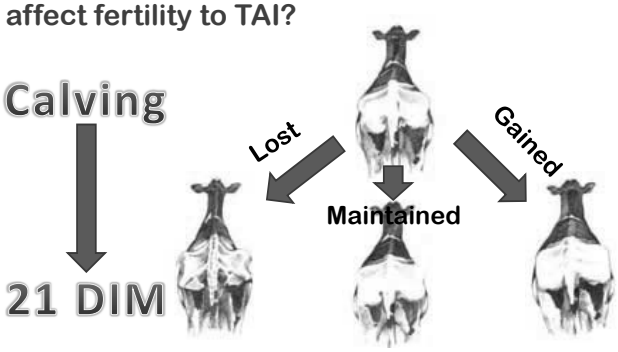
NEFA concentrations



Embryo Characteristics

	Quartile				P-value
	Fourth Q Lost +	Third Q Lost	Second Q Maintain	First Q Gain	
CL (no.)	18.4 ± 2.6	18.4 ± 1.7	19.0 ± 1.7	16.0 ± 2.0	0.67
Fertilized embryos (%)	76.9 ± 7.1	77.0 ± 6.6	77.6 ± 7.6	78.4 ± 7.1	0.99
Quality 1 & 2 embryos (%)	38.0 ± 8.7	61.3 ± 8.2	60.6 ± 9.4	63.4 ± 8.6	0.14
Degenerate embryos (%)	35.2 ± 8.5[a]	12.6 ± 4.6[b]	14.5 ± 6.3[b]	9.6 ± 3.7[b]	0.02
Qual 1 & 2 of Fertilized (%)	48.4 ± 9.5[a]	78.3 ± 6.6[b]	72.6 ± 9.5[b]	77.7 ± 7.4[b]	0.05
Degenerate of Fertilized (%)	46.9 ± 9.6[a,A]	17.4 ± 6.4[b,B]	24.8 ± 9.3[ab,A]	16.2 ± 7.0[b,B]	0.04

Does a change in BCS early postpartum affect fertility to TAI?



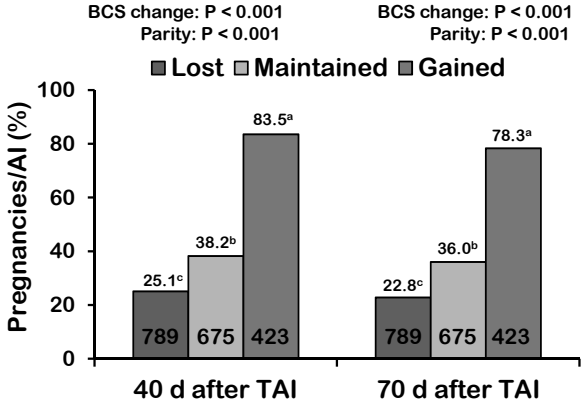
Cows losing more BCS early postpartum will have decreased fertility at first TAI

% of cows, BCS at calving and 21 DIM

	BCS Change			P-Value
	Lost	Maintained	Gained	BCS
% cows	41.8 (789/1887)	35.8 (675/1887)	22.4 (423/1887)	-
% Primi.	47.3 (373/789)	52.7 (356/675)	55.1 (233/423)	0.02
BCS at calving	2.93±0.01[a]	2.89±0.02[ab]	2.85±0.02[b]	0.005
BCS at 21 DIM	2.64±0.01[c]	2.89±0.02[b]	3.10±0.02[a]	<0.001
BCS Δ	-0.29	0.0	+0.25	
ECM (kg/d)[1]	30.9±0.4	31.5±0.4	28.7±0.4	0.3

[1]From calving to 21DIM

P/AI to Double-Ovsynch



Question:

How do I get cows to gain BCS after calving?


Theriogenology 104 (2017) 30–36

Contents lists available at ScienceDirect

Theriogenology

journal homepage: www.theriojournal.com

Association of changes among body condition score during the transition period with NEFA and BHBA concentrations, milk production, fertility, and health of Holstein cows

R.V. Barletta [a, *], M. Maturana Filho [b], P.D. Carvalho [a], T.A. Del Valle [b], A.S. Netto [b], F.P. Rennó [b], R.D. Mingoti [b], J.R. Gandra [d], G.B. Mourão [c], P.M. Fricke [a], R. Sartori [c], E.H. Madureira [b], M.C. Wiltbank [a]

[a] Department of Dairy Science, University of Wisconsin-Madison, Madison, 53706, USA
[b] Department of Animal Nutrition and Production, University of São Paulo, Pirassununga, 13635-900, Brazil
[c] Department of Animal Science, University of São Paulo, Escola Superior de Agricultura Luiz de Queiroz, Piracicaba, 13418-900, Brazil
[d] College of Agricultural Science, Federal University of Dourados, Dourados, 79804-970, Brazil

BCS change from 21 days before calving to 21 days after calving

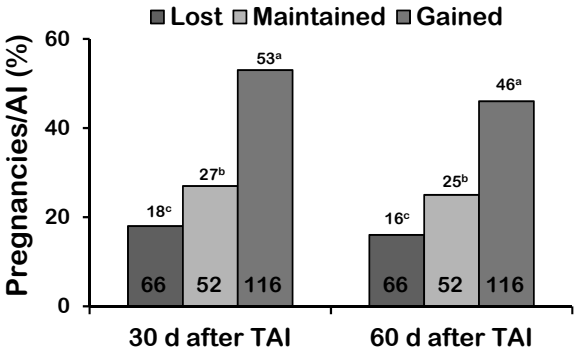
Effect of BCS Change on Health Events

Barletta et al., 2017; Theriogenology 104:30-36.

Event	Lost	Maintained	Gained
	50% (116/234)	22% (52/234)	28% (66/234)
Metritis	23%	21%	20%
Mastitis	29%[b]	17%[a,b]	17%[a]
Ketosis	27%	19%	15%
Pneumonia	15%	12%	9%
>1 Event	63%[b]	46%[a]	39%[a]

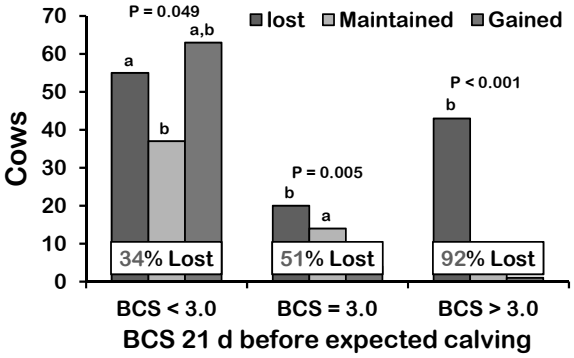
P/AI to TAI after a fertility program

Barletta et al., 2017; Theriogenology 104:30-36



Overall, 50% of cows lost BCS from 21 d before to 21 days after calving

Barletta et al., 2017; Theriogenology 104:30-36



Question:

How do I get cows to gain BCS after calving?

Answer:

Avoid calving overconditioned cows!

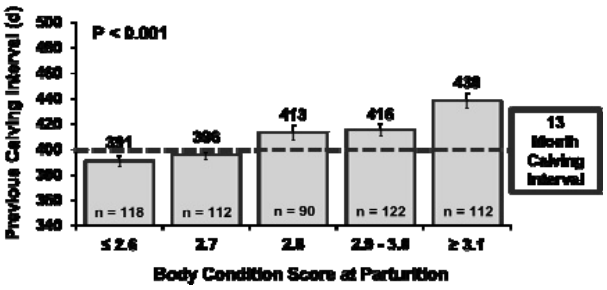
Question:

How do I avoid calving over-conditioned cows?

Calving Interval (13 months = 390 d)		
VWP (60 d)	21-d PR (0 to ? d)	Gestation (282 d)
Fixed	Variable	Fixed

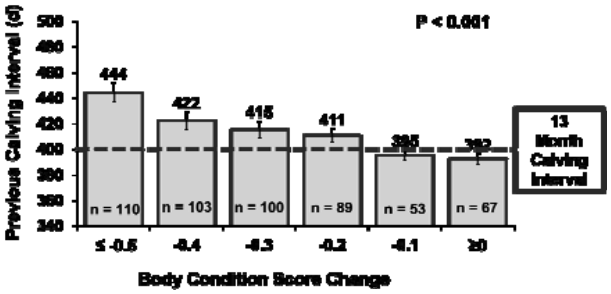
Effect of previous calving interval on BCS at calving

Middleton et al., 2019; J. Dairy Sci. 102:5577-5587



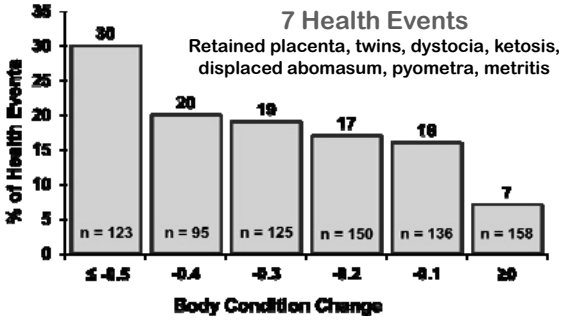
Effect of previous calving interval on BCS change (calving to 30 DIM)

Middleton et al., 2019; J. Dairy Sci. 102:5577-5587



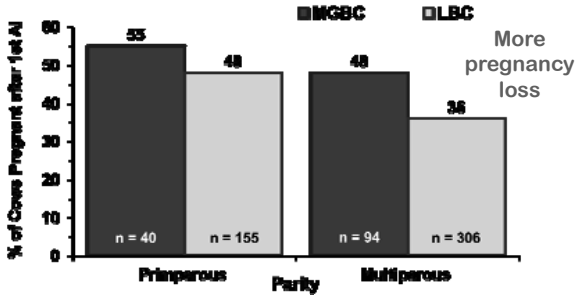
Effect of BCS change on health events

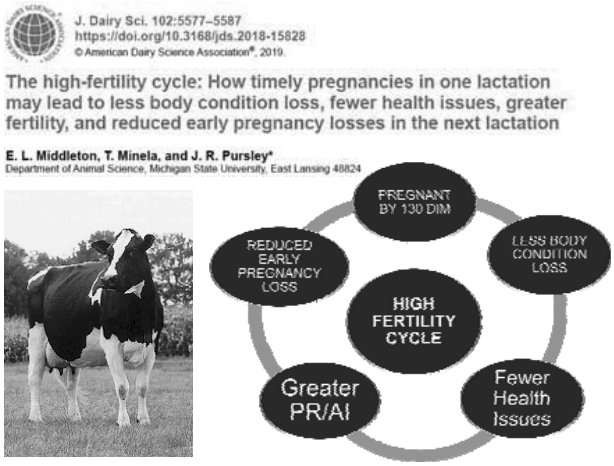
Middleton et al., 2019; J. Dairy Sci. 102:5577-5587



Effect of BCS change after calving on fertility to first TAI

Middleton et al., 2019; J. Dairy Sci. 102:5577-5587





Re-think BCS targets

2001 BCS Recommendations:

Calving: 3.25 to 3.75
Early: 2.50 to 3.25
Mid: 2.75 to 3.25
Late: 3.00 to 3.50
Dry Off: 3.25 to 3.75

Too High!

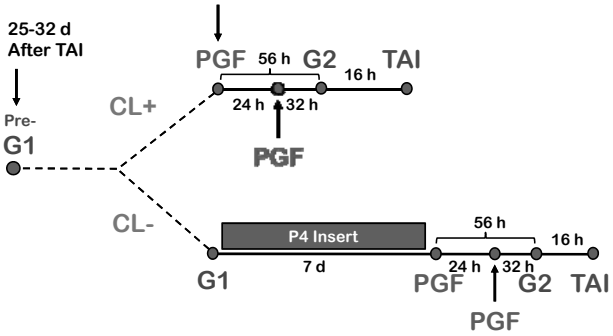
1 2 3 4 5

Emaciated Thin Average Fat Obese

Double-Ovsynch for first TAI

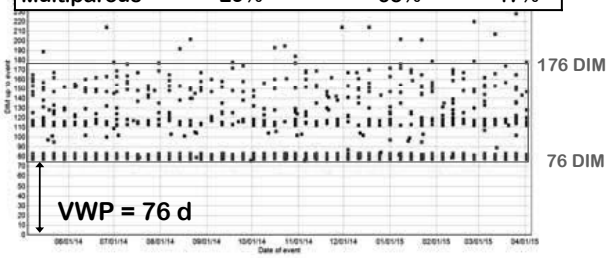
Sun	Mon	Tue	Wed	Thu	Fri	Sat
					GnRH	
					PGF	
	GnRH					
	GnRH					
	PGF	PGF	GnRH	TAI		

Resynch for 2nd and greater TAI



TAI for First Three Inseminations

Parity	21-d Preg Rate	Service Rate	P/AI
All cows	31%	66%	50%
Primiparous	41%	70%	61%
Multiparous	29%	65%	47%



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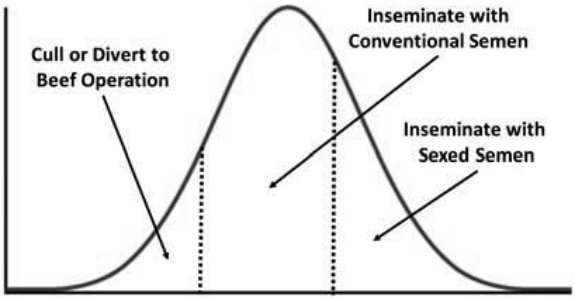
2	47-58	53	153	127	4	13	294	27	1.9
3	62-88	80	72	18	1	0	121	16	1.0
4	36-57	46	31	37	1	1	68	6	1.2
5	21-54	34	10	18	0	1	29	3	1.8
6	-	62	10	6	0	0	16	1	1.0
7	-	50	1	1	0	0	2	0	2.0
8	-	100	1	0	0	0	1	0	1.0
TOTALS	47-53	50	556	549	11	57	1121	100	1.0

90% pregnant after 3 AI

Outline

- A Reproduction Revolution
- The High Fertility Cycle
- New Repro Strategies

Genomics and Sexed Semen

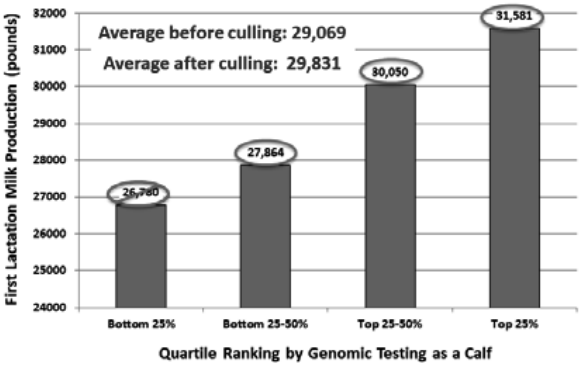


Genomic Testing Heifers in the UW-Madison Dairy Herd

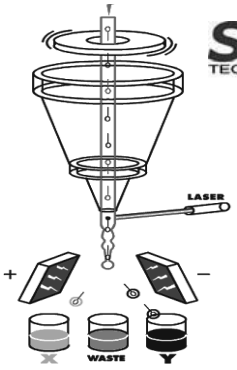
411 Holstein heifer calves were genomic tested with a Zoetis (CLARIFIDE®) chip to predict their future performance

Genomic predictions were compared with actual first lactation milk yield two years later

Genomic Testing Heifers in the UW-Madison Dairy Herd



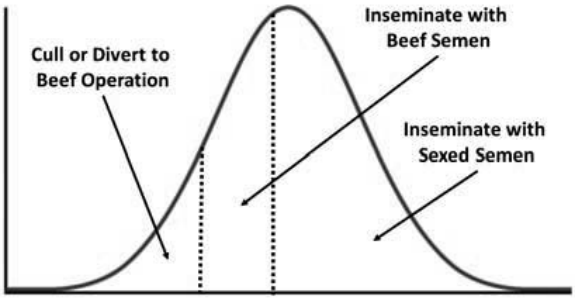
Sexed Semen



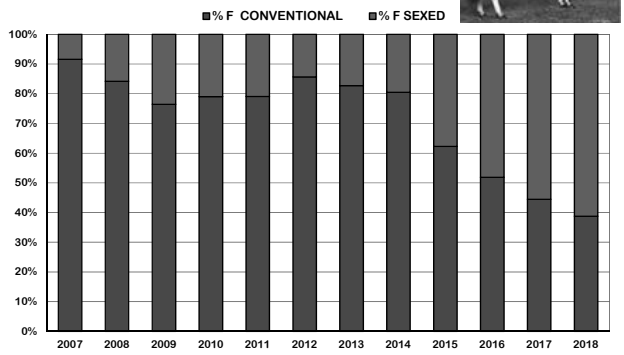
Sexing TECHNOLOGIES Sexcel Sexed Genetics

- X-chromosome has 4% more DNA
- Sperm stained with dye & sorted or killed by laser
- 85% accuracy
- Many sperm are damaged or wasted
- Can sort 8 to 10 straws of semen per hour

Combining Genomics with Sexed Semen and Beef Semen



Female Jersey calves produced by semen type



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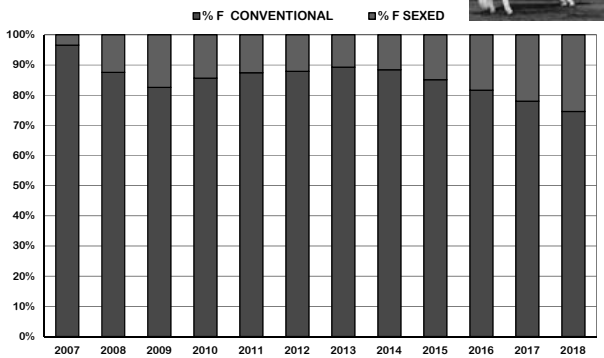
Female Holstein calves produced by semen type



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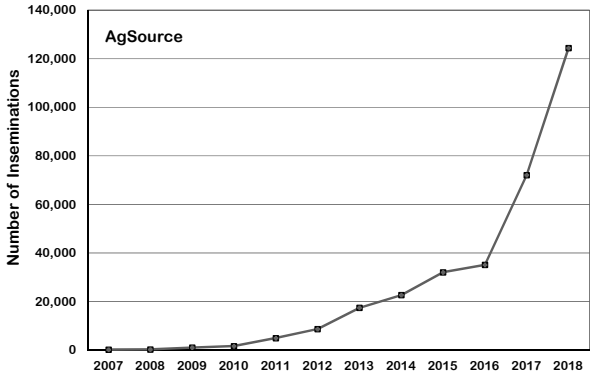
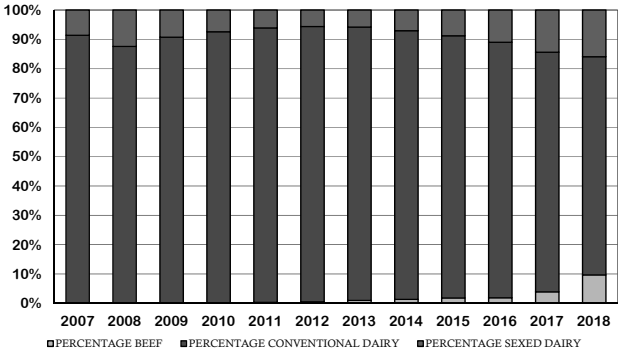
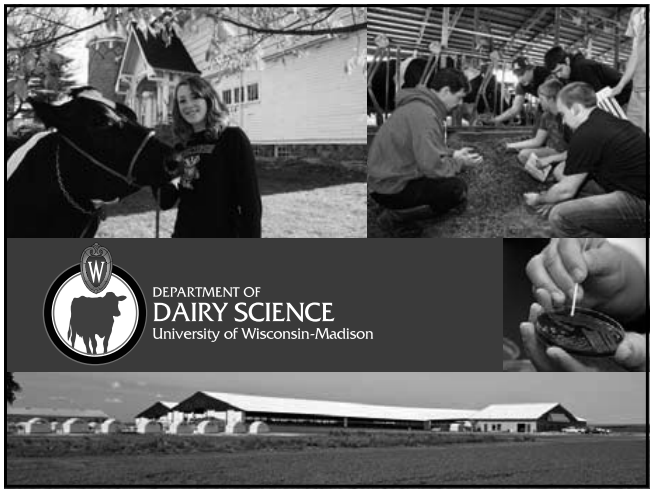
Beef Semen on Dairy Cows



Female Holstein calves produced by semen type





New Research at Miner Institute: Where the Forage Meets the Cow

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Introduction

Miner Institute's fundamental research mission is to link advanced forage-crop management with efficient dairy cattle production to sustain the natural environment. Our contemporary mission grew from William Miner's original vision of science and technology in the service of farming and environmental stewardship.

Current areas of active research at the Institute can be summarized as:

- Forages, fiber, and nutritional strategies
- Stocking density, cow comfort, and feeding management
- Milk analysis as a herd management tool
- Transition cow nutrition and management
- Nutrient management and water quality

A substantial portion of our recent research has focused on overcrowding as a sub-clinical stressor and the impact that secondary stressors such as low dietary fiber or restricted access to feed may have on rumen pH and cow behavioral and performance responses. For example, varying dietary undigested neutral detergent fiber at 240 h of in vitro fermentation (uNDF240) from 8.5 to 9.7% of ration dry matter (DM) resulted in nearly one hour more per day when rumen pH was less than 5.8. But, 100 versus 142% stocking density of free stalls and headlocks increased time below pH of 5.8 by up to 2 h/day. Overcrowding and restricted access to feed during the overnight hours resulted in up to 9 h/d that rumen pH was below 5.8. In general, stocking density and feed management (such as restricted feed access) have a greater impact on rumen pH than dietary uNDF or physically effective NDF (peNDF) content.

So we need to bear in mind that the feeding environment has a substantial modulatory effect on feeding behavior and feed intake. But, this paper will focus primarily on our recent forage research, particularly on uNDF and peNDF relationships.

Forage Research in an Era of Feeding More Forages

Economic, environmental, and even social considerations are encouraging the use of more forage in dairy cattle rations (Martin et al., 2017). Although regional economics and forage availability may determine the balance between dietary forage and non-forage sources of fiber, we appear to be at the threshold of a new era in our ability to effectively feed fiber to lactating dairy cows. Nutritionists have long realized that NDF content alone does not explain all of the observed variation in DM intake (DMI) and milk yield as forage source and concentration in the diet vary. Incorporating measures of fiber digestibility and particle size improves our ability to predict feed intake and productive responses.

Recently, we have focused on the relationship between undigested and physically effective NDF at the Institute, and have conducted a study designed to assess the relationship between dietary uNDF240 and particle size measured as peNDF. The potential interaction between peNDF and uNDF240 is a hot topic among nutritionists with several practical feeding questions being asked in the field:

- What are the separate and combined effects of peNDF and uNDF240 in diets fed to lactating cows?
- Can we adjust for a lack of dietary peNDF by adding more uNDF240 in the diet?
- Similarly, if forage uNDF240 is higher than desired, can we at least partially compensate by chopping the forage finer to maintain feed intake?

The bottom line question is: are there optimal peNDF concentrations as uNDF240 content varies in the diet and vice versa? The answer to this question will likely be affected by the source of fiber: forage or non-forage, since they differ substantially in fiber digestion pools and particle size. Some nutritionists have even questioned how important particle size actually is as we better understand fiber fractions (i.e., fast, slow, and uNDF240) and their rates of digestion. This is a complex question, but the short answer is – yes – particle size is important, although maybe for reasons we haven't always appreciated, such as its effect on eating behavior more so than rumination.

Miner Institute Study: Undigested and Physically Effective Fiber

Dietary Treatments: peNDF and uNDF240. To begin addressing the questions above, we conducted a study in 2018 to assess the effect of feeding lower (8.9% of ration DM) and higher (11.5% of ration DM) uNDF240 in diets with either lower or higher peNDF (19 to 20 versus ~22% of ration DM). The diets contained approximately 35% corn silage, 1.6% chopped wheat straw, and chopped timothy hay with either a lower physical effectiveness factor (pef; fraction of particles retained on ≥1.18-mm screen; 0.24) or a higher pef (0.58). We used a Haybuster (DuraTech Industries International, Inc., Jamestown, ND) with its hammer mill chopping action to achieve the two particle sizes of dry hay. Additionally, for the lower forage diets we partially replaced the timothy hay with nearly 13% pelleted beet pulp to help adjust the fiber fractions. The lower uNDF240 diets contained approximately 47% forage and the higher uNDF240 diets contained approximately 60% forage on a DM basis (Table 1).

A New Concept: Physically Effective uNDF240. To explore the relationship between physical effectiveness and uNDF240 among these four diets, we calculated a "physically effective uNDF240" (peuNDF = pef x uNDF240). In Table 1 we see that this value ranged from 5.4% of DM for the lowUNDF240/low peNDF diet to 7.1% of DM for the high uNDF240/high peNDF diet. And by design, the two intermediate diets contained 5.9% of ration DM.

We expected the bookend diets to elicit predictable responses in DMI based on their substantial differences in uNDF240 and peNDF (Harper and McNeill, 2015). We considered them as "bookends" because these diets represented a range in particle size and indigestibility that would reasonably be observed in the field for these types of diets. And most importantly, we wondered if the two intermediate diets would elicit similar responses in DMI given their similar calculated peuNDF content.

In fact, the high uNDF240/high peNDF diet did limit DMI compared with the lower uNDF240 diets (Table 2). When lower uNDF240 diets were fed, the peNDF did not affect DMI. But, a shorter particle size for the higher uNDF240 diet boosted DMI by 2.5 kg/d. As a result, NDF and uNDF240 intakes were highest for cows fed the high uNDF240 diet with smaller particle size. Overall and as expected, uNDF240 intake was greater for the higher versus lower uNDF240 diets. But, the important take-home result is the 0.45% of BW intake of uNDF240 for cows fed the high uNDF240 diet with hay that had been more finely chopped. The intake of peNDF was driven first by the uNDF240 content of the diet, and then by particle size within each level of uNDF240 (Table 2).

The intake of peuNDF (calculated as the product of pef and uNDF240) was stretched by the bookend diets: 1.47 versus 1.74 kg/d for the low/low versus high/high uNDF240/peNDF diets, respectively. And of greatest interest, we observed that the two intermediate diets resulted in similar peuNDF intake; we were able to elicit the same intake response by the cow whether we fed lower uNDF240 in the diet chopped more coarsely, or whether we fed higher dietary uNDF240, but with a finer particle size.

Lactational Responses to peNDF and uNDF240. Did lactation performance follow these observed responses in feed intake? Generally, milk and energy-corrected milk (ECM) production responded similarly to peuNDF intake (Table 3). In particular, production of ECM was lowest for cows fed the high/high uNDF240/peNDF diet and greatest for the low/low diet (Table 3). Tracking with DMI, the ECM yield was similar and intermediate for the low/high and high/low uNDF240/peNDF diets. Interestingly, milk fat percentage appeared to be more related to dietary uNDF240 than peNDF content.

Chewing Response to peNDF and uNDF240. Dietary uNDF240 and peNDF had a greater impact on eating than ruminating time (Table 4). This observation that dietary fiber characteristics may have a substantial effect on chewing during eating and time spent eating has been observed in several studies. A recent review found that higher forage content, greater NDF or peNDF content, and(or) lower NDF digestibility may all increase time spent eating for a wide range of forages (Grant and Ferraretto, 2018). The cows in our study spent up to 45 min/d, more or less, eating depending on the diet (Table 4). In fact, cows on the high/high uNDF240/peNDF diet spent 45 min/d longer eating and yet consumed nearly 3 kg/d less DM than cows fed the low/low uNDF240/peNDF diet. An important, practical management question is whether or not cows would have sufficient time to spend at the bunk eating with greater dietary uNDF240 that is too coarsely chopped? And with an overcrowded feedbunk environment, the constraint on feeding time could be even more deleterious.

Cows fed the high/high peNDF/uNDF240 diet had the greatest eating time compared with cows fed the low uNDF240 diets (Table 4). Finely chopping the hay in the high uNDF240 diet reduced eating time by about 20 min/d and brought it more in-line with the lower uNDF240 diets.

Part of the reason why eating time was more affected than rumination time is related to the observation that cows tend to chew a bolus of feed to a relatively uniform particle size prior to swallowing. Grant and Ferraretto (2018) summarized research that showed that particle length over a wide range of feeds was reduced during ingestive chewing to approximately 10 to 11 mm (Schadt et al., 2012). Similarly, in our current study, we confirmed that cows consuming all four diets swallowed boli of total mixed ration with a mean particle size of approximately 7 to 8 mm (Table 5) regardless of uNDF240 or peNDF content of the diet.

Ruminal Fermentation: peNDF and uNDF240. Mean ruminal pH followed the same pattern of response as DMI and ECM yield (Table 6). Although not significant, time and area below pH 5.8 numerically appeared to be more related with dietary uNDF240 content than peNDF. Total VFA concentration followed the same pattern as DMI, ECM yield, and mean ruminal pH with cows that consumed similar peuNDF240 having similar total ruminal VFA concentrations (Table 6). Tracking with milk fat percentage, the ruminal acetate + butyrate:propionate ratio was more influenced by uNDF240 than peNDF in our study.

When we assessed ruminal pool size and turnover, we found that the pool size of NDF tended to be greater for cows fed higher uNDF240 diets, and that the pool size of uNDF240 was greater for cows fed these same diets (Table 6). Ruminal turnover rate of NDF tended to be slower for cows fed the higher uNDF240 diets with the high/high uNDF240/peNDF diet having the slowest ruminal turnover of fiber. Overall, the differences among diets in ruminal pool size and turnover were small, but it appeared that higher uNDF240 diets increased the amount of uNDF240 in the rumen and slowed the turnover of NDF. The higher ruminal NDF turnover for cows fed the finely chopped high uNDF240 diet helps to explain the observed increase in DMI.

If future research confirms the results of this initial study, it suggests that when forage fiber digestibility is lower than desired, then a finer forage chop length will boost feed intake and lactational response. The enhanced lactational performance was associated with less eating time as well as more desirable ruminal fermentation and fiber turnover for cows fed the higher uNDF240 diet with lower peNDF. Another important topic that we are currently focusing on is the potential interactions between dietary peuNDF240 and rumen fermentable starch content.

Preliminary Synthesis: Physically Effective, Undigested Fiber, and Cow Responses

We have combined data from four experiments conducted at the Institute to further explore the relationship between dietary uNDF240 and DMI and ECM yield as well as the relationship between dietary peuNDF240 and DMI and ECM yield. The dietary formulations for these four studies were:

- Study 1: the study just described (see Table 1; Smith et al. 2018a; 2018b).
- Study 2: approximately 50 or 65% forage in the ration DM, with 13% haycrop silage (mixed mostly grass), and between 36 and 55% corn silage (either brown midrib 3 or conventional) in ration DM (Cotanch et al., 2014).
- Study 3: approximately 42 to 60% corn silage (brown midrib 3 or conventional) and 2 to 7% wheat straw (finely or coarsely chopped) in ration DM (Miller et al., 2017).
- Study 4: approximately 55% conventional or bm3 corn silage, 2.3% chopped wheat straw (Miner Institute, unpublished, 2019).

Details of ration formulation may be found in the references for each study. Importantly, all of the diets fed in these three experiments were based heavily on corn silage, contained some combination of haycrop silage and chopped straw, and in Study 1 (the current study) two of the diets also contained substantial pelleted beet pulp to formulate the lower uNDF240, lower forage diet.

Figures 1 and 2 illustrate the relationships that we observed when we combined the data from these three studies. For these types of diets, both uNDF240 and especially peuNDF240 appear to be usefully related with DMI and ECM production.

It is important to restrict these inferences to similar diets (corn silage with hay and fibrous byproducts) because more research is required with varying forage types and sources of uNDF (forage versus non-forage) to determine the robustness of the relationships shown in Figures 1 and 2. In particular, legumes such as alfalfa contain more lignin and uNDF240, but have faster NDF digestion rates than grasses, and we might expect different relationships between dietary uNDF240 and DMI for legume- versus grass-based rations. In fact, research has shown that very high levels of uNDF240 intake may be achieved when lactating cows are fed finely chopped alfalfa hay (Fustini et al., 2017) in part because alfalfa contains more uNDF240 than grasses (Palmonari et al., 2014; Cotanch et al., 2014).

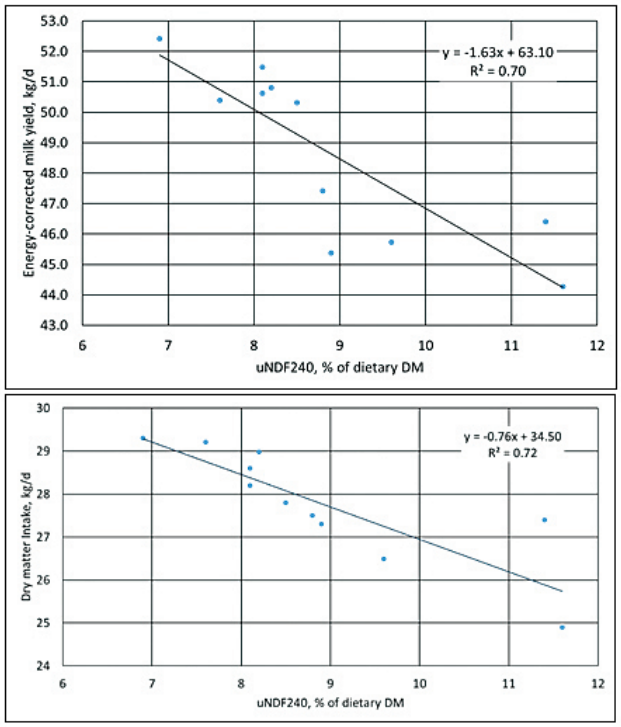

Figure 1. Relationship from three studies between dietary uNDF240 and DMI and ECM yield for cows fed diets based on corn silage, haycrop silage, and chopped wheat straw.

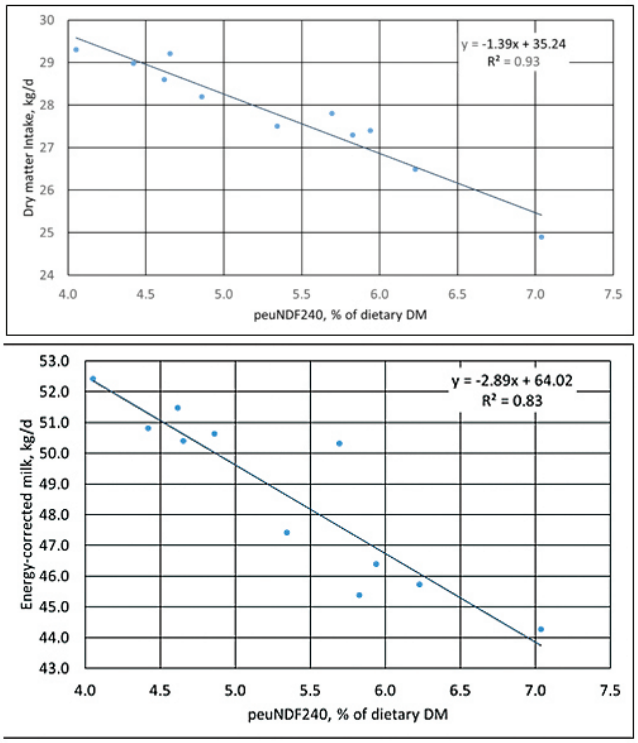

Figure 2. Relationship from three studies between dietary peuNDF240 and DMI and ECM yield for cows fed diets based on corn silage, haycrop silage, and chopped wheat straw (peuNDF240 = physically effective undigested NDF measured at 240 h of in vitro fermentation).

Summary and Perspectives

The calculated "physically effective uNDF240" (pef x uNDF240) appears to be a useful concept when interpreting cow response to the diets fed in this study and studies with similar types of diets. Our goal is not to coin yet another nutritional acronym, but to focus on a potentially useful concept. We were able to elicit the same response by the cow whether we fed lower uNDF240 in the diet with greater peNDF, or whether we fed higher uNDF240, but chopped the dry hay more finely. In other words, the peuNDF240, or integration of pef and uNDF240, was highly related to DMI and ECM yield.

If future research confirms this relationship between dietary uNDF240 and DMI, it suggests that when forage fiber digestibility is lower than desired, then a finer forage chop length will boost feed intake and lactational response. In addition to investigating potential and probable differences between legumes and grasses, we also must understand the potential responses to forage and non-forage sources of fiber.

Integrating two measures of fiber – uNDF240 and peNDF - when formulating rations shows promise as an approach to improve our ability to predict cow response to NDF indigestibility and particle size (Grant, 2018). Research is needed to test this relationship in alfalfa-based diets, pasture systems, and other feeding scenarios that differ markedly from a typical Northeastern and upper Midwestern US diet based primarily on corn silage.

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Table 1. Ingredient and chemical composition of experimental diets (% of DM).

	Low uNDF240[1]		High uNDF240	
	Low peNDF[2]	High peNDF	Low peNDF	High peNDF
Ingredients				
Corn silage	34.7	34.7	34.7	34.7
Wheat straw, chopped	1.6	1.6	1.6	1.6
Timothy hay, short chop	10.5	---	24.2	---
Timothy hay, long chop	---	10.5	---	24.2
Beet pulp, pelleted	12.9	12.9	0.4	0.4
Grain mix	40.3	40.3	39.1	39.1
Composition				
Forage	46.8	46.8	60.5	60.5
aNDFom[3]	33.1	33.3	35.7	36.1
uNDF240om	8.9	8.9	11.5	11.5
peNDFom	20.1	21.8	18.6	21.9
peuNDF240[4]	5.4	5.9	5.9	7.1

[1]Undigested NDF at 240 h of in vitro fermentation.
[2]Physically effective NDF.
[3]Amylase-modified NDF on an organic matter (OM) basis.
[4]Physically effective uNDF240 (physical effectiveness factor x uNDF240).

Table 2. Dry matter and fiber intake for cows fed diets differing in uNDF240 and peNDF.

	Low uNDF240[1]		High uNDF240		SE	*P*-value
Measure	Low peNDF[2]	High peNDF	Low peNDF	High peNDF		
DMI, kg/d	27.5[a]	27.3[a]	27.4[a]	24.9[b]	0.6	<0.01
DMI, % of BW	4.02[a]	4.04[a]	3.99[a]	3.73[b]	0.10	0.03
NDF intake, kg/d	9.12[b]	9.06[b]	9.74[a]	8.96[b]	0.19	0.008
uNDF240om[3] intake, kg/d	2.41[c]	2.43[c]	3.11[a]	2.87[b]	0.05	<0.001
uNDF240om intake, % of BW	0.35[c]	0.36[c]	0.45[a]	0.43[b]	0.01	<0.001
peNDFom intake, kg/d	5.56[b]	5.94[a]	5.07[c]	5.44[b]	0.11	<0.001
peuNDF240[4] intake, kg/d	1.47[c]	1.59[b]	1.61[b]	1.74[a]	0.03	<0.001

[abc]Means within a row with unlike superscripts differ (P ≤ 0.05).
[1]Undigested NDF at 240 h of in vitro fermentation.
[2]Physically effective NDF.
[3]Organic matter.
[4]Physically effective uNDF240 (physical effectiveness factor x uNDF240).

Table 3. Milk yield, composition, and efficiency of solids-corrected milk production.

	Low uNDF240[1]		High uNDF240		SE	*P*-value
Measure	Low peNDF[2]	High peNDF	Low peNDF	High peNDF		
Milk, kg/d	46.1[a]	44.9[ab]	44.0[bc]	42.6[c]	0.9	<0.01
Milk fat, %	3.68[b]	3.66[b]	3.93[a]	3.92[a]	0.10	0.03
Milk true protein, %	2.93[a]	2.88[ab]	2.96[a]	2.84[b]	0.06	0.04
Milk urea N, mg/dl	8.5[c]	9.4[bc]	10.1[ab]	11.0[a]	0.6	<0.01
Energy-corrected milk, kg/d	47.0[a]	45.7[ab]	46.4[ab]	44.6[b]	0.9	0.03
ECM/DMI, kg/kg	1.71[ab]	1.68[b]	1.70[ab]	1.79[a]	0.04	0.02

[abc]Means within a row with unlike superscripts differ (P ≤ 0.05).
[1]Undigested NDF at 240 h of in vitro fermentation.
[2]Physically effective NDF.

Table 4. Chewing behavior as influenced by dietary uNDF240 and peNDF.

	Low uNDF240[1]		High uNDF240		SE	*P*-value
Measure	Low peNDF[2]	High peNDF	Low peNDF	High peNDF		
Eating time, min/d	255[b]	263[b]	279[ab]	300[a]	12	<0.01
Ruminating time, min/d	523	527	532	545	16	0.36

[abc]Means within a row with unlike superscripts differ (P ≤ 0.05).
[1]Undigested NDF at 240 h of in vitro fermentation.
[2]Physically effective NDF.

Table 5. Particle size of swallowed total mixed ration bolus versus diet offered (% retained on sieve; DM basis).

	Sieve size, mm						Mean particle size, mm
Diet	19.0	13.2	9.50	6.70	4.75	3.35	
Low peNDF[1], low uNDF240[2]	3	27	33	20	10	7	9.36
High peNDF, low uNDF240	12	27	29	16	9	6	10.42
Low peNDF, high uNDF240	9	21	23	22	14	11	9.19
High peNDF, low uNDF240	32	13	17	20	11	7	11.55
Bolus							
Low peNDF, low uNDF240	1	11	38	26	14	10	7.96
High peNDF, low uNDF240	3	11	22	29	20	16	7.46
Low peNDF, high uNDF240	2	11	26	29	19	13	7.51
High peNDF, low uNDF240	5	12	19	28	21	14	7.78

[1]Physically effective NDF.
[2]Undigested NDF at 240 h of in vitro fermentation.

Table 6. Ruminal fermentation and dynamics of fiber turnover.

	Low uNDF240[1]		High uNDF240		SE	*P*-value
Measure	Low peNDF[2]	High peNDF	Low peNDF	High peNDF		
24-h mean pH	6.11[b]	6.17[ab]	6.22[ab]	6.24[a]	0.05	0.03
Time pH < 5.8, min/d	253	208	166	164	61	0.24
AUC, pH < 5.8[3]	52.0	49.6	33.5	30.0	15.0	0.29
Total VFA, m*M*	122.8[a]	120.6[ab]	118.3[ab]	112.3[b]	4.1	0.05
Acetate+butyrate:propionate	3.33[c]	3.39[bc]	3.58[a]	3.54[ab]	0.16	<0.01
Ruminal pool size, kg						
OM	12.7	12.3	12.9	12.4	0.5	0.44
aNDFom	8.2	7.9	8.7	8.4	0.4	0.06
uNDF240om	3.8[b]	3.7[b]	4.5[a]	4.4[a]	0.2	<0.01
Ruminal turnover rate, %/h						
OM	8.7	8.8	8.4	8.0	0.4	0.15
aNDFom	4.4[x]	4.4[x]	4.2[xy]	3.9[y]	0.2	0.04
uNDF240om	2.7	2.8	3.0	2.7	0.1	0.29

[abc]Means within a row with unlike superscripts differ (P ≤ 0.05).
[xy]Means within a row with unlike superscripts differ (P ≤ 0.10).
[1]Undigested NDF at 240 h of in vitro fermentation.
[2]Physically effective NDF.
[3]Area under curve pH < 5.8; ruminal pH units below 5.8 by hour.